United States Court of Appeals

for the

District of Columbia Circuit

TRANSCRIPT OF RECORD

JOINT APPENDIX

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

No. 18,935

KENNETH E. LYMAN,

Plaintiff-Appellant,

v.

DAVID L. LADD,
COMMISSIONER OF PATENTS,

Defendant-Appellee.

Appeal from the United States District Court for the District of Columbia

INDEX

DOCKET ENTRIES

1963	
Apr. 23	Complaint appearance
Apr. 23	Summons, copies (3) and copies (3) of Complaint issued, U.S. Atty. ser. 4-24; Atty. Gen. ser. 4-24; ser. 4-25
Jun. 8	Answer of deft. to complaint; c/m 6-7-63; app. of C.W. Moore, filed
Jun. 8	Calendared (AC/N) (N)
1964	
Mar. 3	Appearance of Joseph F. Nakamura as co-attorney for deft. filed
Mar. 3	Heard and taken under advisement; counsel to submit briefs and findings of fact and conclusions of law and order. (Rep.-Jack Maher) Jackson, J.
May 12	Stipulation of counsel allowing defendant until May 21, 1964, to submit brief, proposed findings of fact, conclusions of law and order. (fiat) (N)
June 5	Motion of plaintiff for leave to file answer brief for plaintiff; Exhibit; c/m 6-5-64; M.C. 6-5-64
August 4	Pre Trial Brief of Plaintiff
August 4	Trial brief for defendant
August 4	Brief of Plaintiff and proposed findings of fact and conclusions of law and order
August 4	Stipulation of counsel allowing deft until May 22, 1964 to file brief and proposed findings of fact, etc.
August 4	Transcript of proceedings dated March 3, 1964; Pages 59 (Court's copy)
August 4	Memorandum of Opinion and Findings of Fact and Conclusions of Law in favor of the defendant and dismissing complaint (N) Jackson, J.
August 4	Order dismissing complaint with all costs against pltff. (N) Jackson, J.
August 4	All exhibits returned to counsel.
August 25	Notice of appeal by plaintiff from order of August 4, 1964; deposit $5.00 by Parker. (copy mailed to C. W. Moore)
Sept. 14	Transcript of proceeding 3/3/64, pages 1-59. (Attorneys copy)

[Filed, April 23, 1963]

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA CIRCUIT

KENNETH E. LYMAN,
2240 West Grand Boulevard
Detroit 8, Michigan

Plaintiff,

v.

DAVID L. LADD, Commissioner
of Patents, Washington, D.C.,

Defendant.

Civil Action No. 1059-63

COMPLAINT UNDER USC TITLE 35, SECTION 145, SEEKING ALLOWANCE OF CLAIMS IN PLAINTIFF'S PENDING PATENT APPLICATION

To the Honorable the Judges of the District Court
of the United States for the District of Columbia:

KENNETH E. LYMAN, the Plaintiff herein, brings this Complaint against DAVID L. LADD, Commissioner of Patents, Defendant, and alleges that:

1. The Plaintiff herein, KENNETH E. LYMAN, is a resident of Detroit, in Wayne County, in the State of Michigan.

2. The Defendant, DAVID L. LADD, is the United States Commissioner of Patents, and is officially a resident of Washington, in the District of Columbia, within the jurisdiction of this court.

3. This action is brought under the provisions of USC Title 35, Section 145.

4. On or about the 14th day of September, 1959, the Plaintiff herein, KENNETH E. LYMAN, executed an application for Letters Patent for an "Automotive Independent Wheel Suspension System", invented by him.

5. On or about the 5th day of October, 1959, the said Plaintiff duly made application in writing in the United States Patent Office for the grant of Letters Patent to him for said "Automotive Independent Wheel Suspension System," which application was given Serial No. 844,408.

6. Plaintiff makes profert of a certified copy of the aforesaid application for Letters Patent, Serial No. 844,408, and all proceedings and papers in the file thereof, together with certified copies of the patents relied upon by the Patent Office during the prosecution of said application for Letters Patent, said certified copies to be produced as and when this honorable court shall direct.

7. Said application Serial No. 844,408 contains claims 1 to 7, inclusive, to which Plaintiff believes himself entitled.

8. Thereafter, said application for Letters Patent was examined by the Examiner in charge thereof who, on the 25th day of August, 1961, finally rejected said claims 1 to 7, inclusive, on the basis that said claims were unpatentable over the prior art as represented by the patents to Metz, No. 2,202,665, and Siebler, No. 2,122,961, and a publication "Vibration of Rail and Road Vehicles" by B. S. Cain, pages 84-86, published in 1940; on the 12th day of December, 1961, an appeal was duly taken to the Board of Appeals of the United States Patent Office and on the 27th day of September, 1962 said Board of Appeals rendered its decision on said claims 1 to 7 which affirmed the Examiner with respect to his rejection thereof. Thereafter and within the thirty-day period provided for by Rule 197 of the Rules of Practice, Plaintiff petitioned the Board of Appeals for reconsideration of its decision. The Board of Appeals denied Plaintiff's petition for reconsideration on April 9, 1963.

9. Plaintiff alleges that the decision of the Board of Appeals adjudging that claims 1 to 7, inclusive, are unpatentable over the prior art was erroneous and contrary to law.

10. Plaintiff further alleges that no appeal has been taken by him to the United States Court of Customs and Patent Appeals from said refusal of said Commissioner of Patents to allow claims 1 to 7, inclusive, and that the complaint herein is filed within the thirty-day period following the decision by the Board of Appeals on Plaintiff's aforementioned petition for reconsideration as provided for by Rule 304 of the Rules of Practice.

WHEREFORE, Plaintiff respectfully prays as follows:

(A) For a decree that claims 1 to 7, inclusive of Plaintiff's application are patentable over the prior art;

(B) For a decree pursuant to USC Title 35, Section 145, authorizing the Commissioner of Patents to issue a patent to Plaintiff containing claims corresponding to said claims 1 to 7, inclusive.

(C) That Plaintiff have such other and further relief as the nature of the case may permit and require and as may be just and equitable.

Respectfully,

/s/ N. D. Parker, Jr.

1518 K Street, N.W.
Washington 5, D.C.

Attorney for Plaintiff

E. S. Booth
Bair, Freeman & Molinare
135 South La Salle Street
Chicago 3, Illinois

[Filed, June 8, 1963]

ANSWER TO COMPLAINT

To the Honorable the Judges of the United States District Court for the District of Columbia

1, 2, 3. The defendant admits the allegations of paragraphs 1, 2, and 3 of the complaint.

4. The defendant admits that on the 14th day of September, 1959, the plaintiff herein, Kenneth E. Lyman, executed an application for Letters Patent for an "Automotive Independent Wheel Suspension System." The defendant asserts that, otherwise, he is without knowledge or information sufficient to form a belief as to the truth of the allegations of paragraph 4 of the complaint.

5, 6. The defendant admits the allegations of paragraphs 5 and 6 of the complaint.

7. The defendant admits that application Serial No. 844,408 contains claims 1 to 7, inclusive. Otherwise, however, the defendant denies the allegations of paragraph 7 of the complaint.

8. The defendant admits the allegations of paragraph 8 of the complaint.

9. The defendant denies the allegations of paragraph 9 of the complaint.

10. The defendant admits the allegations of paragraph 10 of the complaint.

FURTHER ANSWERING, the defendant asserts that the plaintiff is not entitled to a patent containing any of claims 1 through 7 of his application involved in this civil action, for the reasons given and in view of the references cited in the Examiner's answer and the decisions of the Board of Appeals in that application. Profert hereby is made of copies of the said answer, decisions, and references.

Respectfully submitted,
/s/ C. W. Moore,
Solicitor, United States Patent Office, Attorney for Defendant

[Certificate of Service, June 7, 1963]

PLAINTIFF'S EXHIBIT 1 [Oct. 5, 1959]
[1] 844,408

SPECIFICATION

(Case No. 58,320)

TO ALL WHOM IT MAY CONCERN:

Be it known that I, KENNETH E. LYMAN, a citizen of the United States, and resident of the Village of Hinsdale, County of Du Page, State of Illinois, have invented certain new and useful improvements in an

AUTOMOTIVE INDEPENDENT
WHEEL SUSPENSION SYSTEM

of which the following is a specification:

This invention relates to the mathematical apportionment of the

suspension arm elements and the elastic spring elements in an automotive independent wheel suspension system.

As apportionment is the crux of this invention the scope hereof is limited to said apportionment and said apportionment in combination with certain other system structural elements not herein specifically claimed.

The ideal wheel suspension system for a vehicle would absorb but would not transmit to the vehicle the vertical wheel motion reaction forces occasioned by road travel, would have road travel effortless precision wheel steering control, and would maintain constant maximum tire adhesion with the road.

[2]

For the purposes of definition "road travel" herein used means a car operating speed of more than 25 mph and road irregularities of height not to exceed the action limit of the suspension. For car speeds under 25 mph road irregularities are smoothly and resiliently transferred to the vehicle.

Road travel impacts are accepted by invention independent wheel suspension system in any time element but recovery is controlled by apportionment caused action.

A general object of invention system is great increase of safety in car operation by elimination of detrimental force effects inherent in present production systems and which are a major contributing cause of road accidents.

Another general object of invention system is car direction under-steering control providing road travel substantially effortless-positive-precision car direction steering.

Another general object of invention system is more continuous and greater tire-road adhesion contact effected by apportionment.

Another general object of invention system is to enhance the riders comfort by negligible transmission of road travel irregularities to the vehicle.

In an apportioned wheel suspension system the only road travel vertical force of moment transmitted to the vehicle is the change in

spring loading, a relatively small force compared to the inertia mass of the vehicle, and causing negligible movement

[3]

of the vehicle's horizontal plane. In road travel the only shift of the vehicle's horizontal plane is angular in response to changes of road gradient or crown.

The prime object of invention system is to effect by apportionment substantially synchronous downward motion of the wheel mass and spring.

In present production systems the wheel mass and spring move downward in out of phase action creating residual rebound force effects requiring shock absorber dampening. Shock absorbers transmit road irregularities to the vehicle and also retard wheel recovery for tire road contact.

Another object is to provide a wheel suspension system with maximum freedom of vertical wheel motion with substantially no friction effects in the suspension arms.

Production suspension systems have high friction arm pivots which transmit road reactions to the vehicle and retard wheel recovery for tire road contact.

Another object is to provide a wheel suspension system where equal length suspension arms cause the wheel to move transversely vertically in parallel planes.

In production suspension systems the unequal length suspension arms cause the wheel to move vertically in an arcuate path thereby creating gyroscopic forces of thousands of pounds at high car speeds.

[4]

Another object is to provide a wheel suspension system where equal length apportioned suspension arms create a force couple absorbed in the mounting bracket, in reaction to transverse road force effects.

In production suspension systems having unequal length suspension arms the transverse road reaction forces present when making a turn

result in a force couple acting on the inward pivots of the arms thereby increasing the force effects causing car roll and to correct for the induced car roll a transverse torsion rod is added.

Another object is to provide a wheel suspension where the steering king pin pivot is located in the centerplane of the wheel thereby causing road reaction forces to function at zero leverage and creating an understeering wheel direction control which results in effortless precision car direction control in road travel and permits instantaneous steering response in getting out of car tracks, ruts, or getting back on the road from the burm. Apportionment with the king pin in the centerline of the wheel eliminates road wander and provides stabilized car direction control.

Production suspension systems have the steering king pin pivot located angularly outside of the vertical plane of the wheel thereby increasing the reaction forces transmitted to the steering elements in the suspension system and causing an oversteering condition which results in car wander and steering

[5]

reactions to car direction control which are particularly dangerous when getting out of car tracks, ruts, or getting back on the road from the burm.

Another object is to provide a wheel suspension system where apportionment equilibrium of forces with freedom for vertical motion of suspension system elements causes greatly improved maintenance of maximum tire adhesion with the road.

Production suspension systems with shock absorber action, friction in suspension arm pivots and rebound forces disturb maintenance of tire adhesion contact with the road.

Another object is to provide a wheel suspension system where the wheel bearings are substantially equally spaced from the center plane of the wheel and where all of the forces acting on the wheel are substantially in the center plane of the wheel.

Production suspension systems have quite complex force patterns of reaction forces incident to the functioning of the system. These re-

action forces are transmitted to diverse locations in the system and in one high production present wheel suspension system the force diagram is so complex that it results in variable forces of magnitude acting simultaneously in seven continually varying directions of lines of action, in seven continually varying angles of action and in seven continually varying leverages of action.

Another object is to provide a wheel suspension system where said apportionment causes substantially equilibrium balance

[6]

resolution of all the forces and reaction forces incident to road travel at the intersection of the wheel rotation center line with the center plane of the wheel.

In a number of invention independent wheel suspension systems built and tested, the car's original equipment springs and tires were used and it was found that no wheel-tire balancing was required for road speeds in excess of 90 mph.

The tire elements used in a wheel suspension system have three upward resilient reaction forces which are tire tread material flow spread under load, tire casing deflection under load and tire air pressure. These reaction forces each function at nondisturbing frequencies in a system and in combination absorb road travel vertical forces with negligible rebound effects.

Life road and performance tests on effects of tire wear and spring fatigue established that a 5% reduction in wheel mass weight effects and 7 1/2% reduction in spring rate per inch show no appreciable effects in suspension functioning except harder ride characteristics.

Life and performance tests of invention wheel suspension system included tests of a number of different types of suspension arm constructions, tests of transverse, angular and trailing arm suspension arm mountings, tests of suspension arms with and without torque arm stabilizers, tests of front and rear, dirigible and driven wheel mounting constructions, tests of metal spring elements which also function as suspension arms in both pivoted

[7]

and seated constructions, and tests of a number of different types of elastic spring elements including tests of fluid, rubber type composition and metal spring in coil, leaf, torsion and Bellevue types. Tests established factually that said apportionment is applicable to any combination of usable physical and elastic elements.

As said apportionment is effective in any usable combination, we have selected one independent wheel suspension design, which has been thoroughly tested, for the drawings to which reference is made hereinafter.

One reason for the design selected is that the performance characteristics of the system very closely approaches that of the ideal system hereinbefore mentioned.

Another reason for the design selected is that, while the apportionment mathematics can be modified to apply to other suspension system designs, this design has the most simple mathematics of apportionment.

The above and other objects and features of the invention will be more readily apparent from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic top elevation of a typical chassis equipped with a wheel suspension system embodying the invention;

Figure 2 is a top elevation of a single suspension system with parts broken away;

[8]

Figure 3 is an end elevation of the system of Figure 2 with parts broken away;

Figure 4 is an end elevation of a diagrammatic line drawing of the suspension system;

Figure 5 is a simplified line diagram illustrating action of the suspension system; and

Figure 6 is a diagram illustrating action of the spring only.

As an object of apportionment is maximum equilibrium balance in system action with minimum residual force effects the distance of ap-

portioned action is taken as equal to the distance from the system's upper action limit to the horizontal postion of static loading but apportioned distance is equally divided above and below said horizontal position.

While apportionment may be applied to other limits, the limits here used, for a number of reasons, are practical and effective.

Said reasons include:

1,—In considerably more than 99.99% of road travel the system's vertical motion is within apportioned limits, a condition hereinafter called "normal road travel."

2,—In normal road travel the wheel mass moves downward at a constant rate of acceleration and the spring moves downward at a harmonic-frequency rate of acceleration.

3,—In normal road travel the increase in downward force effect of wheel mass motion substantially equals, in value, the decrease in spring loading.

4,—In normal road travel the force inter-exchange between the wheel mass and the spring is negligible.

5,—In normal travel substantially continuous maximum tire-road adhesion contact is maintained by the substantially constant spring loading by the weight of the vertically substantially static chassis structure.

6,—In normal road travel the upward vertical forces cause changes in spring loading and the downward vertical forces are those of wheel mass motion, and as said forces have negligible reaction effects, it can be said a condition of practical equilibrium balance exists.

7,—For system's road travel downward motion for apportioned distance the mathematics of apportionment is correct; for lesser motion within limits of apportionment the mathematics is substantially correct; and for system's motion from any upward position but not exceeding the vertical limits of apportioned distance the mathematics is practically correct.

8,—For system's road travel maximum downward motion, or for a lesser distance greater than the distance of apportionment, apportionment functioning is effective for a distance the equivalent of apportioned distance and thereafter the wheel mass motion force effects accelerate recovery of tire-road contact with minor motion effects on the chassis structure.

An automotive independent wheel suspension system having mathematical apportionment fulfills the herein objects

with a simple practical structure of appreciable weight reduction and major cost reduction.

Mathematical apportionment is dimensional resolution of the system's elements to cause downward co-action functioning of the wheel mass structure suspension elements and the elastic spring structure elements for equivalent distance of motion in a common time period for the distance of apportioned control.

Mathematical apportionment is a new ratio combination of old elements resulting in a plurality of new desirable effects.

The mathematics for apportioned action in a wheel suspension system entails development of formulae for the functioning of the structural elements incorporated and for the functioning of the type spring elements incorporated, and by equating the mathematics of the two formulae requisite changes in the elements results in apportionment equality.

Figures 1 to 3 show a typical vehicle construction involving a wheel suspension system embodying the invention. Figure 1 illustrates a plan view of a vehicle chassis having side members 10 joined by cross members 11 at its ends and with intermediate cross members 12 extending between the side members. An engine 13 may be supported on the chassis at one end of the vehicle, and it will be understood that the chassis also supports a body which may be a separate body mounted on the chassis or which may be in the form of a monocoque construction. The chassis is supported on four wheels 14, which may be conventional

[11]

automotive vehicle wheel structures carrying the usual pneumatic tires and provided with the usual brakes of any desired type. The wheels 14 are connected to the chassis through suspension linkages indicated generally at 15 and which are constructed to embody the mathematical apportionment of the present invention. It will be understood that the wheels at one end of the chassis are pivoted on king pins for steering the vehicle; whereas, the wheels at the opposite end of the chassis are on fixed axes.

Figures 2 and 3 illustrate in more detail the individual wheel suspension linkages, and particularly the linkages for suspending the steerable wheels. As shown, each of the side frame members 10 carries a mounting block 16 on which the suspension linkage is mounted, although if desired, the linkage could be directly connected to the chassis or to brackets on the chassis. Each of the suspension linkages comprises a bearing block 17 in which a stub axle 18 is journaled with the wheel and brake drum shown at 19 being fixedly secured to the stub axle. The bearing block 17 is mounted for turning about a vertical axis on vertically aligned pivots 21 carried by a yoke member 22, and which axis lies in the center plane of the wheel 14 and is vertical. For steering suitable linkage not shown is connected to the wheels to turn them about the vertical axis defined by the pivots 21 in the usual manner. It is important to note, however, that the vertical pivotal axis lies in the center plane of the wheel [12] and is truly vertical so that all reaction forces on the wheel are absorbed directly by the linkage without creating any turning forces on the wheel and without producing gyroscopic effects as the wheel moves vertically relative to the chassis. The yoke 22 is supported on upper and lower arms 23 and 24 which are of the same length and which lie in parallel spaced relation to each other. Each of the arms is pivoted at one end to horizontal bearings on the mounting block 16 and at its opposite end to horizontal bearings on the yoke 22 to define a true parallelogram linkage as a result of which the wheel will remain vertical as it moves up or down relative to the chassis. With this construction the bearings at the ends of the arms can be, and preferably are, antifriction bearings so that frictional resistance to movement of

the arms is minimized, and they can swing freely in response to forces developed by movement of the vehicle over a road.

Spring means is provided to urge the ~~bearing block~~ yoke 22 and the wheel downward relative to the chassis so that the chassis will be resiliently supported on the wheels. As shown in Figures 2 and 3, the spring means comprises a cantilever leaf spring 25 fixedly mounted at one end on the chassis and the mounting block 16 and pivotally connected at its opposite end to the upper end of the bearing block 22. The leaf spring 25 lies parallel to the arms 23 and 24 and is of substantially the same effective length as the arms so that it can deflect freely in response to loads imposed upon it. While a leaf spring has been illustrated

[13]

for purposes of simplicity as mentioned above, it will be understood that various other types of springs can be used in connection with the invention and with the same advantages.

The operation of the suspension linkage will be better understood by references to Figures 4 to 6. Figure 4 is a line diagram generally similar to Figure 3 and with the lines corresponding to the different linkage elements of Figure 3 being indicated by the same reference numerals. In this diagram the weight of the wheel mass and the equivalent weight of the linkage mass is illustrated by a circle 26.

It will be seen that as the mass 26 moves vertically relative to the fixed chassis part 10, it will travel in an arc about a center 27 lying between the pivotal axes of the arms 23 and 24 to the chassis structure. The movement of the mass may, therefore, be considered equivalent to movement of a mass pivoted at 27 and connected to its pivot by a lever indicated by the dot-dash line 28.

The diagram can, therefore, be simplified further for purposes of analysis as illustrated in Figure 5, wherein the mass 26 is shown pivoted through a single link 28 to a pivotal axis 29. In this diagram

the length of the lever 28 is shown as L, the total vertical movement of the mass 26 as S, with the total movement divided into S/2 above the horizontal position of the lever 28 and an equal amount of movement below the horizontal position of the lever 28. The angle of the lever

relative to the vehicle is shown as the angle θ and the angles through which the lever moves during springing movements as α with one-half of α being above and the other half below the horizontal position of the lever 28.

For vertical motion of the wheel the general equation of motion is:

$$\omega = \frac{d\theta}{dt} = \pm 2\sqrt{\frac{g}{L}} \times \sqrt{\sin^2\frac{\theta_0}{2} - \sin^2\frac{\theta}{2}}$$

In this case θ_0 being real $(0<\theta_0<\pi)$ the above equation is solved by means of the substitution $\sin\frac{\theta}{2} = \sin\frac{\theta_0}{2}\sin\varphi$ giving:

$$\omega = \frac{d\varphi}{dt} = \sqrt{\frac{g}{L}}\sqrt{1-\sin^2\frac{\theta_0}{2}\sin^2\varphi}$$

and the value of time

$$t = \sqrt{\frac{L}{g}}\int_0^{\varphi}\frac{d\varphi}{\sqrt{1-\sin^2\frac{\theta_0}{2}\sin^2\varphi}}$$

When the wheel is at its highest position $\theta = \theta_0$ and φ equals $\frac{\pi}{2}$.

When the wheel is at its lowest position $\theta = 90^\circ - \frac{\alpha}{2}$ and $\frac{\theta}{2} = 45 - \frac{\alpha}{4}$. It follows that $\sin\left(45-\frac{\alpha}{4}\right) = \sin\frac{\theta_0}{2}\sin\varphi$ and

$$\sin\varphi = \frac{\sin\left(45-\frac{\alpha}{4}\right)}{\sin\frac{\theta_0}{2}}$$

But $\sin\frac{\theta_0}{2} = \frac{\sqrt{2}}{2}\left(\cos\frac{\alpha}{4}+\sin\frac{\alpha}{4}\right)$ giving: $\sin\varphi = \dfrac{\frac{\sqrt{2}}{2}\left(\cos\frac{\alpha}{4}-\sin\frac{\alpha}{4}\right)}{\frac{\sqrt{2}}{2}\left(\cos\frac{\alpha}{4}+\sin\frac{\alpha}{4}\right)}$

or expressed in terms of "L" and "S": $\sin\varphi = \dfrac{2L-S}{\sqrt{4L^2-S^2}}$

and $\varphi = \arcsin\left(\dfrac{2L-S}{\sqrt{4L^2-S^2}}\right)$ which constitutes the lower limit for the integration. Furthermore: $\sin\frac{\theta_0}{2} = \frac{\sqrt{2}}{2}\left(\cos\frac{\alpha}{4}+\sin\frac{\alpha}{4}\right)$ and

$$\sin^2\frac{\theta_0}{2} = \frac{1}{2}\left(1+\sin\frac{\alpha}{2}\right) = \frac{2L+S}{4L}$$

In order to make the integration possible (elliptic integral), the expression under the square root is expanded:

$$\left[1-\sin^2\frac{\theta_0}{2}\sin^2\varphi\right]^{-\frac{1}{2}} = \left[1-\left(\frac{2L+S}{4L}\right)\sin^2\varphi\right]^{-\frac{1}{2}} = 1-\left(-\frac{1}{2}\right)\left(\frac{2L+S}{4L}\right)\sin^2\varphi +$$
$$\frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)}{1\times 2}\left(\frac{2L+S}{4L}\right)^2\sin^4\varphi + \frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)\left(-\frac{1}{2}-2\right)}{1\times 2\times 3}\left(\frac{2L+S}{4L}\right)^3\sin^6\varphi + \ldots$$

It is sufficient to take only the first three terms of the expansion, the series converging rapidly, because $\left(\frac{2L+S}{4L}\right)\sin^2\varphi < 1$

The time T_1, necessary for the wheel to move from its highest point to the lowest position will be:

$$T_1 = \sqrt{\frac{L}{g}}\int_{\arcsin\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right)}^{\frac{\pi}{2}}\left[1+\left(\frac{2L+S}{8L}\right)\sin^2\varphi + \frac{3}{8}\left(\frac{2L+S}{4L}\right)^2\sin^4\varphi + \ldots\right]d\varphi$$

Giving after integration and substitution of limits:

$$T_1 = \sqrt{\frac{L}{g}}\left[\varphi + \left(\frac{2L+S}{8L}\right)\left(\frac{\varphi}{2}-\frac{1}{4}\sin 2\varphi\right) + \frac{3}{8}\left(\frac{2L+S}{4L}\right)^2\left(\frac{3}{8}\varphi - \frac{1}{4}\sin 2\varphi + \frac{1}{32}\sin 4\varphi\right)\right]_{\arcsin\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right)}^{\frac{\pi}{2}}$$

$$T_1 = \sqrt{\frac{L}{g}}\left[\frac{\pi}{2} + \left(\frac{2L+S}{8L}\right)\frac{\pi}{4} + \frac{3}{8}\left(\frac{2L+S}{4L}\right)^2\frac{3\pi}{16} - \arcsin\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right)\right.$$
$$-\left(\frac{2L+S}{8L}\right)\left(\left(\frac{1}{2}\arcsin\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right) - \frac{\sqrt{2S(2L-S)}}{2(2L+S)}\right)\right)$$
$$+\frac{3}{8}\left(\frac{2L+S}{4L}\right)^2\left(\left(\frac{3}{8}\arcsin\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right) - \frac{\sqrt{2S(2L-S)}}{2(2L+S)}\right.\right.$$
$$\left.\left.\left.+\frac{1}{32}\times 4\left(\frac{2L-S}{\sqrt{4L^2-S^2}}\right)\sqrt{1-5\frac{(2L-S)^2}{4L^2-S^2} + 8\frac{(2L-S)^4}{(4L^2-S^2)^2} - 4\frac{(2L-S)^6}{(4L^2-S^2)^3}}\right)\right)\right]$$

Figure 6 is a diagram of the cantilever spring 25 illustrating the manner of solution of the vertical vibration of the spring considered functioning as a cantilever beam loaded only by its own weight and deflected from its horizontal position of equilibrium by an impulsive force. The equation for the period of vibration T_2 is obtained as follows.

The method is based on the principle that the maximum potential energy is equal to the maximum kinetic energy. For a beam of uniform cross section the maximum potential energy is expressed:

$$E_P = \frac{1}{2EI}\int_0^L M^2 dx = \frac{EI}{2}\int_0^L \left(\frac{d^2y}{dx^2}\right)^2 dx \text{ --}$$

where M = bending moment: E = modulus of elasticity = 30.10^6 psi, and I = moment of inertia about a transverse axis, perpendicular to the beam.

The kinetic energy of the beam may be expressed as:

$$E_K = \frac{1}{2}\int_0^L \frac{w}{g}(y\omega)^2 dx$$

where w = weight per unit length (8) and ω is the circular frequency of vibration in rad/sec. Equating (7) and (8) the following equation is obtained:

$$EI\int_0^L \left(\frac{d^2y}{dx^2}\right)^2 dx = \frac{w}{g}\omega^2\int_0^L y^2 dx \text{ and } \omega^2 = \frac{EI_g\int_0^L \left(\frac{d^2y}{dx^2}\right)^2 dx}{W\int_0^L y^2 dx} \quad (9)$$

In order to solve equation (9) by elementary methods the method of Rayleigh is used, consisting in assuming for the beam a reasonable

deflection curve. The closest result to the extremely difficult and laborious exact mathematical solution is obtained by assuming that the dynamic deflection curve is proportional to the static deflection curve, the latter being one of the simple standard cases in Strength of Materials.

According to the above assumption the deflection of the vibrating beam is expressed: $y = Ay$ static, where A is a coefficient of proportionality.

Substituting this relation into equation (9) gives:

$$\omega^2 = \frac{EI_g \int_0^L A^2 \left(\frac{d^2 y_{static}}{dx^2}\right)^2 dx}{W \int_0^L A^2 y^2_{static}\, dx} = \frac{EI_g \int_0^L \left(\frac{d^2 y_{static}}{dx^2}\right)^2 dx}{W \int_0^L y^2_{static}\, dx} \quad \text{-- (10)}$$

The static deflection curve of a cantilever beam, loaded by its own weight is:

$$y = \frac{Wx^2}{24EI}(x^2 + 6L^2 - 4Lx) \text{ or } y = \frac{W}{24EI}(x^4 + 6L^2x^2 - 4Lx^3) \quad (11)$$

hence $\quad \frac{dy}{dx} = \frac{W}{24EI}(4x^3 + 12L^2x - 12Lx^2)$

and $\quad \frac{d^2y}{dx^2} = \frac{W}{24EI}(12x^2 + 12L^2 - 24Lx) = \frac{W}{EI}\left(\frac{x^2}{2} + \frac{L^2}{2} - Lx\right) \quad (12)$

Substituting the value for $\frac{d^2y}{dx^2}$ from (12) into (9)

$$\omega^2 = \frac{EI_g \int_0^L \left(\frac{W}{EI}\right)^2 \left(\frac{x^2}{2} + \frac{L^2}{2} - Lx\right)^2 dx}{W \int_0^L \left(\frac{Wx^2}{24EI}\right)^2 (x^2 + 6L^2 - 4Lx)^2 dx}$$

giving after integration and substitution of limits:

$$\omega^2 = \frac{EI_g}{W} \times \frac{\frac{L^5}{20}}{\frac{1}{576} \times \frac{104L^9}{45}} = 12.46 \frac{EI_g}{WL^4}$$

and $\quad \omega = 3.53\sqrt{\frac{EI_g}{WL^4}}$

[18]

The period of vibrations $T_2 = \frac{2\pi}{w} = \frac{2\pi}{3.53}\sqrt{\frac{WL^4}{EIg}}$ (15)

Making $T_1 = \frac{1}{2}T_2$ permits for given "S" and dimensions of the leaf spring (for I) to determine the length "L" of the arm of the parallelogram. Alternatively if "L" is assumed, the width and depth of the spring may be determined.

With a suspension system constructed in accordance with the invention the wheel will move vertically upward or downward relative to the chassis as it strikes irregularities in the road surface over which the vehicle is moving. Upward impact forces will be partially absorbed by the tire, and the tire must necessarily absorb all impact forces which are more rapid than the rate at which the wheel can move. In general, however, the wheel will move upward relative to the chassis an amount approximately equal to the height of a bump in the road surface at a rate determined by the steepness of the bump and the rate of travel of the vehicle. Recovery of the wheel to contact with the road surface is governed by the ~~resonant~~ coaction of the a suspension linkage to the [illegible] and the frequency rate of motion of the spring. As pointed out above, these are made equal or substantially equal according to the present invention and are not dampened by appreciable friction forces so that the recovery will be extremely rapid. Since the rate of movements ~~resonant coaction~~ of the spring and of the suspension linkage are equal, no resultant forces will be
time [illegible] movements

[19]

present and the wheel will move downward smoothly and rapidly relative to the chassis to maintain maximum road contact under all conditions without the production of any residual forces requiring dampening.

The suspension of the steering wheel for turning movement about its center plane gives better steering control with the elimination of gyroscopic forces or side forces tending to turn the wheel. This, together with the improved road contact achieved by the suspension system contributes very materially to safety of operation and greatly improved handling of the vehicle on the road.

While one embodiment of the invention has been shown and described herein, it will be understood that it is illustrative only and not to be taken as a definition of the scope of the invention, reference being had for this purpose to the appended claims.

[20]

WHAT IS CLAIMED IS:

1. In a vehicle suspension system including a vehicle frame, a wheel, linkage means connecting the wheel to the frame for vertical movement relative thereto and a spring acting on the linkage means urging the frame upward relative to the wheel, the improvement comprising B² ~~providing the wheel and linkage means with a time-motion-distance downward movement about the pivotal connection of the linkage to the frame equal to the time-distance frequency of functioning of the spring.~~

Ins B²

2. The suspension system of claim 1 in which the wheel is pivotally connected to the linkage means for turning movement about a vertical axis lying in the center plane of the wheel.

3. The suspension system of claim 1 in which the time required for the wheel to move from its highest to its lowest position is equal to one-half of the period of vibration of the spring.

[21]

4. In a vehicle suspension system including a vehicle frame, a wheel, a generally horizontal linkage pivoted at one end to the frame and at the other end to the wheel to support the frame on the wheel, and a spring acting on the linkage and urging the frame upward relative to the wheel, the improvement which comprises so construction and relating the ~~length of the~~ linkage to the spring as to provide a natural timed downward movement of the linkage about its pivotal connection to the vehicle frame equal to the natural ~~period of the spring~~ motion.

Ins B³

5. The spring suspension of claim 4 in which the spring is a cantilever spring with one end secured to the frame and the other end secured to the linkage to the wheel.

6. The spring suspension of claim 4 in which the wheel is supported for turning movement about a vertical axis lying in its center plane and carried by a yoke to which the linkage is pivoted.

7. The spring suspension of claim 6 in which the linkage is a parallelogram linkage supporting the wheel for parallel movement.

[22]

OATH, POWER OF ATTORNEY, AND PETITION

58, 320

Being duly sworn, I, KENNETH E. LYMAN, depose and say that I am a citizen of the United States, residing at Hinsdale, Illinois; that I have read the foregoing specification and claims and I verily believe I am the original, first, and sole inventor of the invention or discovery in

AUTOMOTIVE INDEPENDENT WHEEL SUSPENSION SYSTEM

described and claimed therein; that I do not know and do not believe that this invention was ever known or used before my invention or discovery thereof, or patented or described in any printed publication in any country before my invention or discovery thereof, or more than one year prior to this application, or in public use or on sale in the United States for more than one year prior to this application; that this invention or discovery has not been patented in any country foreign to the United States on an application field by me or my legal representatives or assigned more than twelve months before this application; and that no application for patent on this invention or discovery has been filed by me or my representatives or assigned in any country foreign to the United States.

And I hereby appoint BAIR, FREEMAN & MOLINARE, 135 South LaSalle Street, Chicago 3, Illinois, Registration No. 11,566, as my attorneys, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith.

Wherefore I pray that Letters Patent be granted to me for the invention or discovery described and claimed in the foregoing specification and claims, and I hereby subscribe my name to the foregoing specification and claims, oath, power of attorney, and this petition.

Inventor /s/ Kenneth E. Lyman

Post Office Address 2240 W. Grand Boulevard
Detroit 8, Michigan

State of MICHIGAN
County of WAYNE SS

Before me personally appeared KENNETH E. LYMAN *to me known to be the person described in the above application for patent, who signed the foregoing instrument in my presence, and made oath before me to the allegations set forth therein as being under oath, on the day and year aforesaid, this* 14th *day of* September, 1959.

[SEAL]

/s/ Constance Smith,
Notary Public

96.2

[23]

844498 DIV. 47

1959 OCT 26

#2

PRINT OF DRAWING AS ORIGINALLY FILED

Fig.1

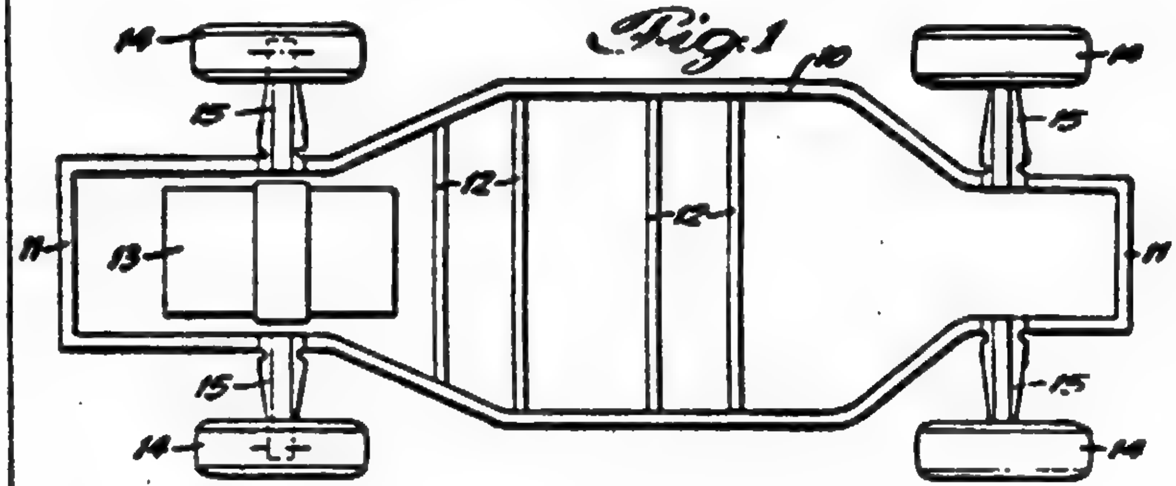
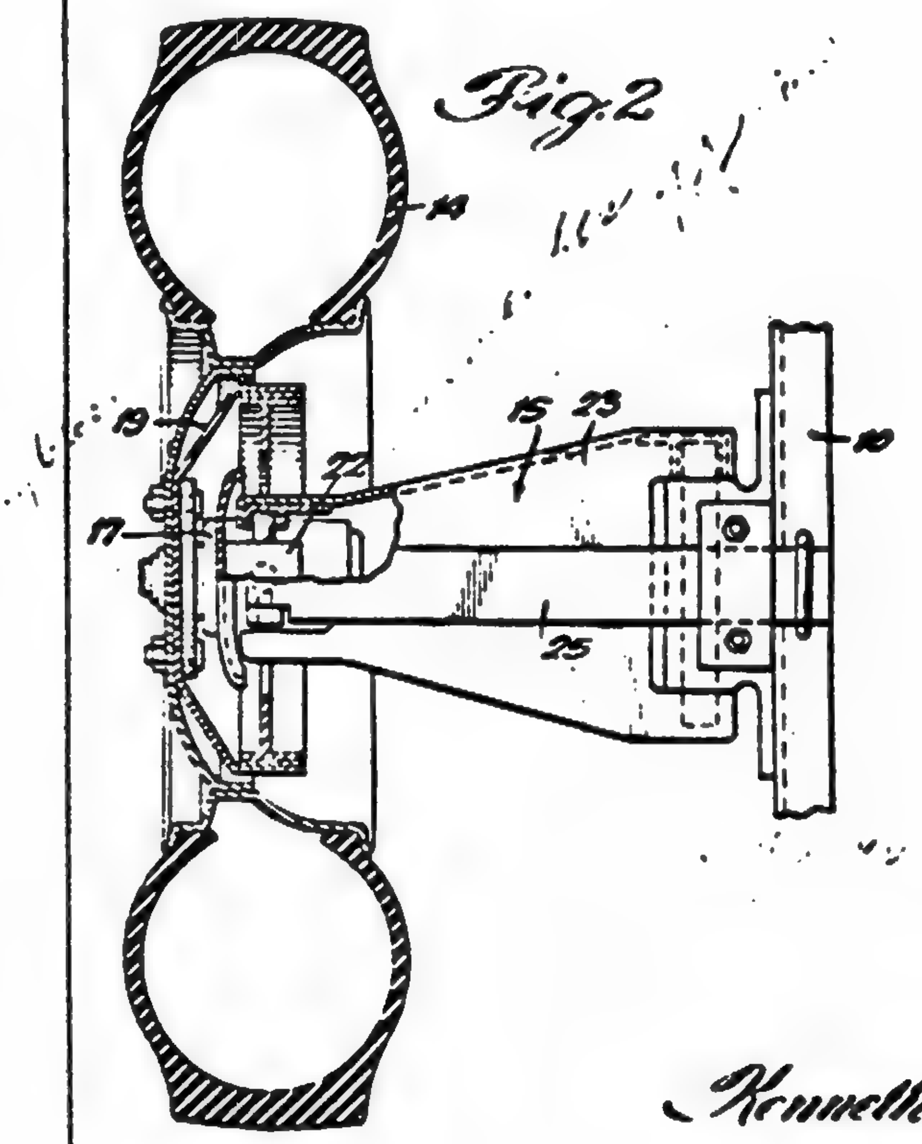


Fig.2



INVENTOR:
Kenneth E. Lyman.

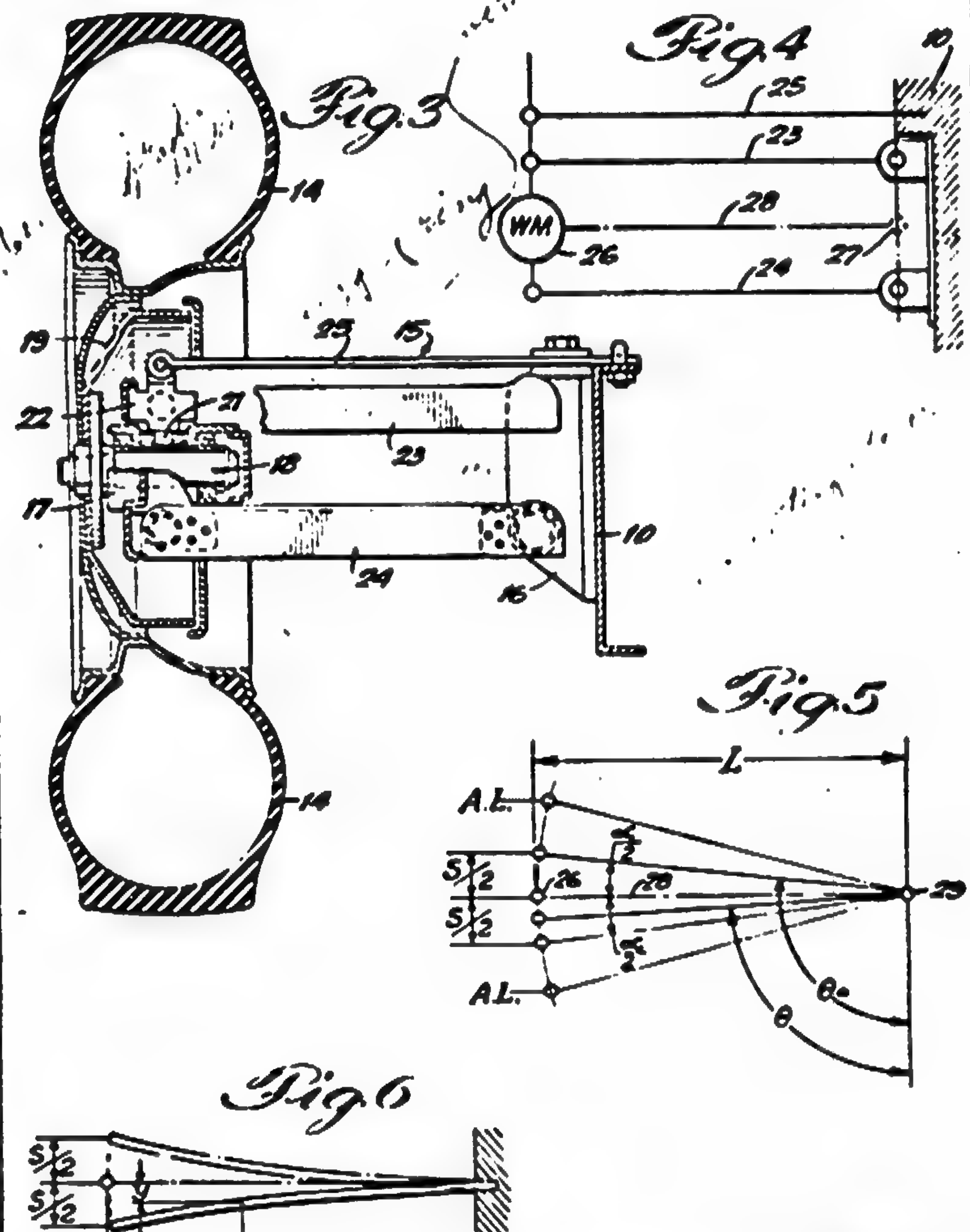
BY Bair Freeman & Molinare
ATTORNEYS.

JA 23

[24]

844408

PRINT OF DRAWINGS AS ORIGINALLY FILED



INVENTOR:
Kenneth F. Lyman.

BY Blair Freeman & Molinare
ATTORNEYS.

[June 30, 1960, U.S. Patent Office] [27]

IN THE UNITED STATES PATENT OFFICE

In the Application of	)	
KENNETH E. LYMAN	)	
Serial No. 844,408	)	DIV. 47
Filed October 5, 1959	)	
AUTOMOTIVE INDEPENDENT WHEEL SUSPENSION SYSTEM	)	

AMENDMENT

Hon. Commissioner of Patents
Washington 25, D.C.

Sir:

In response to the Office Action of April 7, 1960 please amend the above entitled application as follows:

Page 11, line 22, before "For" insert—

a' Although only the upper pivot 21 is shown in Figure 3 it will be understood that there is a similar pivot aligned therewith and pivotally engaging the lower side of the bearing block 17.

Page 12, line 17, change "bearing block" to—yoke—.

Page 18, line 17, cancel "resonant";

same line, before "suspension" insert—

a² time-motion distance downward movement of the wheel about the pivotal connection of the

same line, after "linkage" insert—to the frame—;

line 18, before "spring" insert—frequency rate of motion of the—;

[28]

Page 18, line 21, change "resonsant coaction" to—

rate of movements—.

[Apr. 24, 1961, U.S. Patent Office]

IN THE UNITED STATES PATENT OFFICE

IN RE APPLICATION	)	
KENNETH E. LYMAN	)	
SERIAL NO. 844,408	)	Division 47
FILED: October 5, 1959	)	
FOR: AUTOMOTIVE INDEPENDENT WHEEL SUSPENSION SYSTEM	)	

AMENDMENT

Hon. Commissioner of Patents
Washington 25, D.C.

Sir:

In response to the Office Action of October 31, 1960, please amend the above-entitled application, as follows:

Page 11, Line 22, following the insert before "For" insert the following sentence—

> The yoke 22 as shown comprises upper and lower blocks carrying bearings for the pivots 21 and rigidly connected by an annular disc 22a which encircles the bearing block 17.

Claim 1, starting with "providing the wheel" in Line 5, cancel the remainder of the claim and insert—

> so constructing and proportioning the spring that the frequency controlled rate of downward movement of the point therein which acts on the linkage is equal to the gravity affected rate of downward movement of the point in the linkage acted on by the spring.

Claim 4, Line 6, before "relating" insert—constructing and—;

Same Line, cancel "length of the";

Line 8, after "frame" insert—when the wheel moves downward—;

[36]

Rewrite the last line to read—

B3

period of movement of the spring whereby there is no resultant transfer of energy between the spring and the linkage when the wheel moves downward relative to the frame.

. . .

[44]

[Apr. 24, 1961, U.S. Patent Office]

LETTER TO CHIEF DRAFTSMAN

Hon. Commissioner of Patents
Washington 25, D.C.

Sir:

Please amend Figures 2 and 3 of the drawings in the above-entitled application by adding thereto the reference numeral 22a, as shown in red on the attached prints.

Please charge the cost of this correction to the account of Bair, Freeman & Molinare, Account No. 02-325, Order No. 61/104.

Respectfully submitted,
/s/ Bair, Freeman & Molinare
/s/ E. S. Booth, Attorney

April 17, 1961
Attachments

Fig: 1

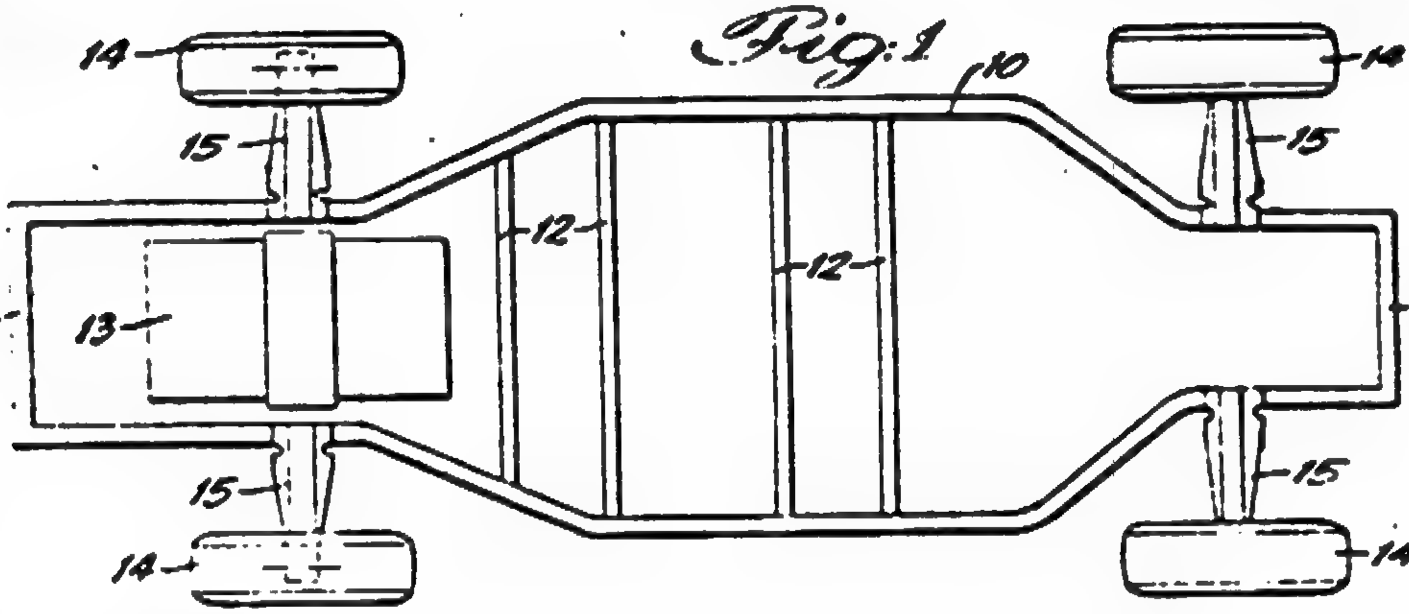
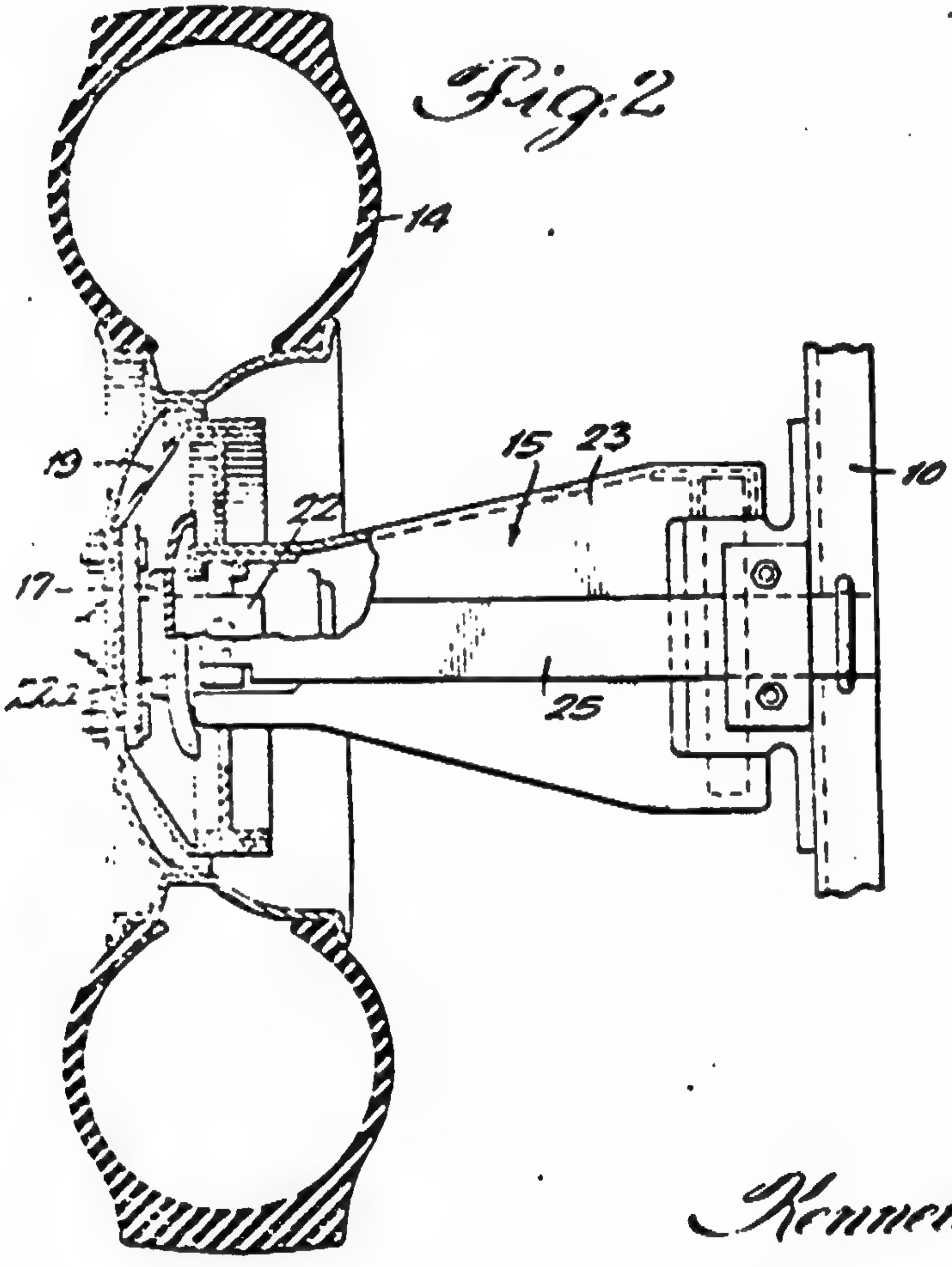


Fig: 2

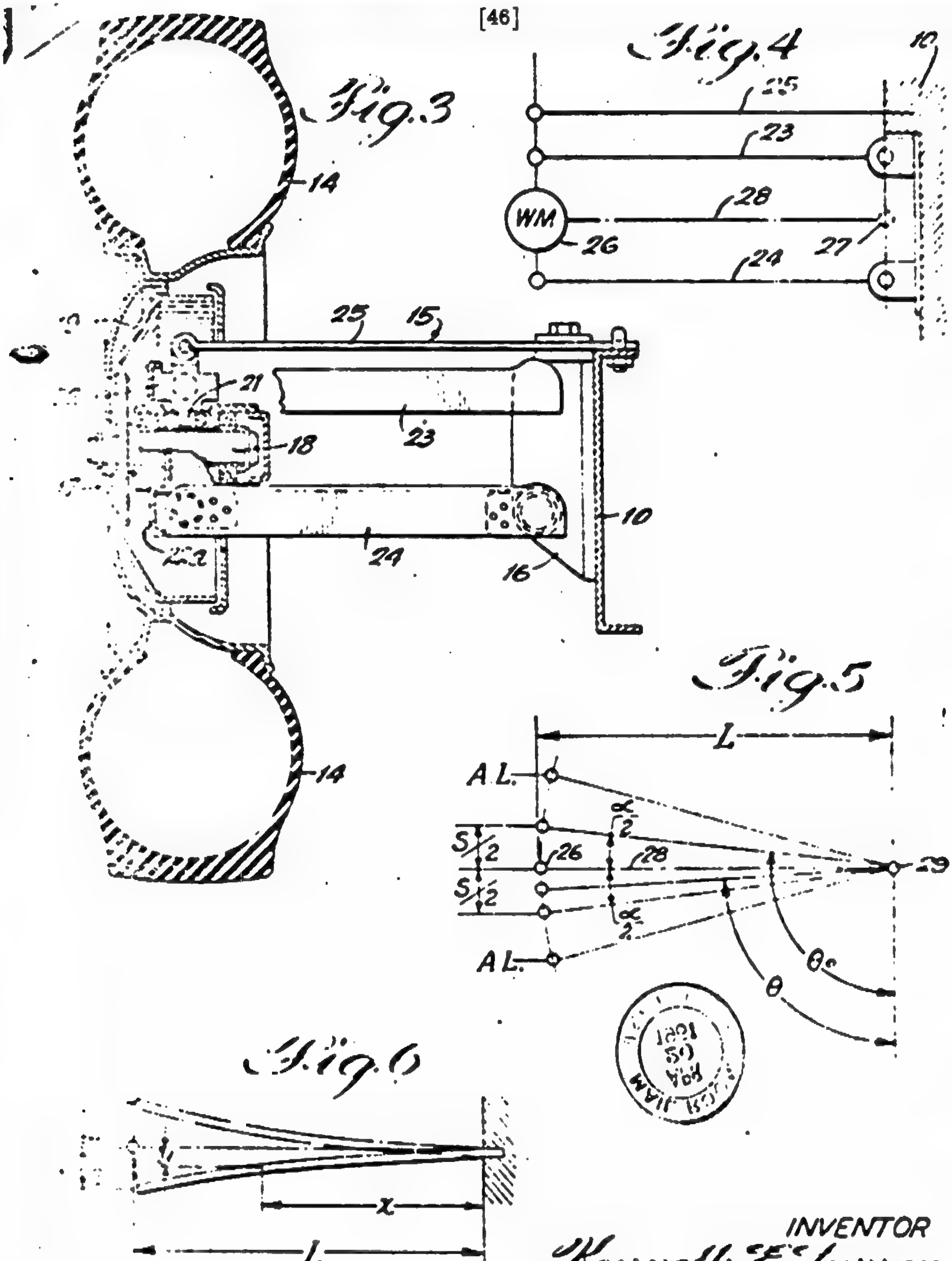


INVENTOR:

Kenneth E. Lyman.

BY Bair Freeman & McLeigrie

ATTORNEYS.



INVENTOR
Kenneth E. Lyman:

BY [illegible]
46 ATTORNEYS

[47]

[Mailed August 25, 1961]

FINAL REJECTION

Responsive to the amendment of April 20, 1961.

The requirement for condensing the material on pages 1-7 is hereby repeated. Applicant's remarks in the above amendment have been considered, but it is still believed that some reduction is necessary. For example, the material on page 6, lines 14-18 could be incorporated in the detailed description, and lines 8-10 of page 5 could be cancelled as it is well-known that rebound forces disturb tire adhesion. Rule 73 requires that a brief summary be provided, and it is believed not more than four pages should be adequate to set forth the objects.

The comments made by applicant at the recent interview with Examiner and the remarks submitted with the amendment of April 20, 1961, have been very carefully considered. However, notwithstanding the Examiner is of the opinion the claims fail to define invention over the art of record for the reasons hereinafter set forth.

Claim 1 is rejected as unpatentable over Metz, of record. In the patented structure, the linkage means, which includes parallel links 35, 36 and radius rod 21, connects wheel support 43, 81 to the frame 11, 13. Leaf spring 14 is attached to the frame member 13 at its center and at one of its outer ends to the wheel support. On page 6, column 1, lines 42-72, it is stated that if the component parts are such as to establish frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no shock absorber is necessary. Also, it is stated that the wheel mass and radius rod have a definite frequency and the spring has an established frequency, and by making the linkage 35, 36 of a proper length a correlated frequency is established. It would be a matter of design not amounting to invention to proportion the spring 14 of Metz so that the frequency controlled rate of downward movement of one of its outer ends is equal

to the gravity effect rate of downward movement of the linkage and wheel mass, instead of proportioning the length of his links and radius rod.

Claim 2 is rejected on the same reference as claim 1. The wheel of Metz turns about a pivot axis which is slightly inwardly of the center plane of the wheel as shown in Fig. 1. To have the pivot axis of Metz positioned exactly in the center plane of the wheel would be a matter of choice or design.

Claim 3 is rejected as unpatentable over the same reference as claim 1. Metz established equivalent frequencies, as mentioned above in the rejection of claim 1.

Claims 4-7 are rejected as unpatentable over Metz in view of Siebler (or record) and the Vibration of Rail and Road Vehicles publication (of record). The links of Metz are pivoted to the frame and to the yoke 43 which mounts the wheel, and the radius rod is rigid with the yoke and pivoted to the frame. Siebler teaches the use of parallelogram linkage 4, 7 and spring 5 for suspending a wheel, and the radius rod of Metz could be omitted without the exercise of invention. Metz states that the wheel mass, spring, and linkage have a definite frequency of functioning. The radius rod is made long so that its frequency will be low and will function with the wheel as a weight effect, and the links are related to the frequency of the spring, wheel mass and radius rod. It would not be invention to proportion the links of Metz to have the natural periods of downward movement of the links equal to the period of movement of the spring when the radius rod is omitted. Such formulas as are set forth in pages 84-86 of the publication could be utilized when proportioning the linkage to the spring, if desired.

The above rejection of claims 1-7 is now made final.

FINAL REJECTION

/s/ P. Arnold
Examiner

[54]

Dec. 19, 1961, U.S. Patent Office, Board of Appeals]

NOTICE OF APPEAL

Hon. Commissioner of Patents
Washington 25, D.C.

Sir:

Applicant hereby appeals to the Board of Appeals from the decision of the Principal Examiner finally rejecting claims 1 to 7, inclusive.

Respectfully submitted,
/s/ Bair, Freeman & Molinare
/s/ E. S. Booth, Attorney

December 8, 1961

[55]

Dec. 19, 1961, U.S. Patent Office, Board of Appeals]

BRIEF ON BEHALF OF APPLICANT

This appeal comes before the Honorable Board of Appeals from the final rejection of Claims 1 to 7, inclusive, constituting all of the claims in the application.

The claims on appeal read as follows:

—1. In a vehicle suspension system including a vehicle frame, a wheel, linkage means connecting the wheel to the frame for vertical movement relative thereto and a spring acting on the linkage means urging the frame upward relative to the wheel, the improvement comprising so constructing and proportioning the spring that the frequency controlled rate of downward movement of the point therein which acts on the linkage is equal to the gravity effected rate of downward movement of the point in the linkage acted on by the spring.—

—2. The suspension system of claim 1 in which the wheel is pivotally connected to the linkage means for turning movement about a vertical axis lying in the center plane of the wheel.—

[56]

—3. The suspension system of claim 1 in which the time T_1 required for the wheel to move from its highest to its lowest position within the specification limits is equal to 1/2 T_2 where T_2 equals the time required for one cycle of vibration of the spring.—

—4. In a vehicle suspension system including a vehicle frame, a wheel, a generally horizontal linkage pivoted at one end to the frame and at the other end to the wheel to support the frame on the wheel, and a spring acting on the linkage and urging the frame upward relative to the wheel, the improvement which comprises so constructing and relating the linkage to the spring as to provide a natural timed downward movement of the linkage about its pivotal connection to the vehicle frame when the wheel moves downward equal to the natural period of movement of the spring whereby there is no resultant transfer of energy between the spring and the linkage when the wheel moves downward relative to the frame.—

—5. The spring suspension of claim 4 in which the spring is a cantilever spring with one end secured to the frame and the other end secured to the linkage to the wheel.—

—6. The spring suspension of claim 4 in which the wheel is supported for turning movement about a vertical axis lying in its center plane and carried by a yoke to which the linkage is pivoted.—

[57]

—7. The spring suspension of claim 6 in which the linkage is a parallelogram linkage supporting the wheel for parallel movement.—

The references relied on are as follows:

Metz	2,202,665
Siebler	2,122,961

Publication: "Vibration of Rail and Road Vehicles" by B. S. Cain; pages 84-86; published in 1940.

[69]

In re application of
Kenneth E. Lyman
Ser. No. 844,408
Filed October 5, 1959
For Automotive Independent
Wheel Suspension System

Appeal No. 27-40
Before the Board of Appeals

Bair, Freeman & Molinare For Appellant

EXAMINER'S ANSWER

This is an appeal from the final rejection of claims 1-7, all the claims in the case.

The amendment of December 12, 1961, has not been entered. The proposed amendment to claim 3 would render this claim indefinite since the expression "within the specification limits" is not clear. An amendment to the specification can be made at a later date in the event applicant has a favorable decision on the appeal.

A correct copy of the appealed claims appears on pages 1-3 of applicant's brief except for claim 3. The appeal will be on claim 3 as originally filed, since the proposed amendment to this claim has not been entered as mentioned above.

[70]

The references of record relied on are:

Siebler	2,122,961	July 5, 1938
Metz	2,202,665	May 28, 1940

Publication: "Vibration Of Rail And Road Vehicles" by B. S. Cain; pages 84-86; published in 1940 (copy available in Div. 45).

The alleged invention relates to vehicle spring suspensions. Each of the front wheels 14 are connected to the chassis by linkages 15. Mounting block 16 (Fig. 3) is secured to frame member 10, and upper and lower parallel arms 23, 24 are pivoted to the mounting block and to yoke member 22. The yoke member is carried by bearing block 17 in

which the stub axle 18 is journalled. Vertically aligned pivots 21 on the yoke member permit steering the wheel about a vertical axis which lines in the center plane of the wheel. The cantilever leaf spring 25 is rigidly secured at its inner end on the frame member and mounting block, and is pivotally secured at its other end to the yoke member. The spring extends parallel to the arms and resiliently supports the chassis relative to the wheel. In Fig. 4, the weight of the wheel mass and equivalent weight of the linkage is illustrated by a circle 26 that is pivoted at 27 on a lever 28, and in Fig. 5 for purposes of analysis the mass 26 on lever 28 is shown as having a length L. The vertical movement of the mass is the distance S about a pivotal axis 29 with S/2 being the amount below the horizontal position of the lever. The angle θ is the angle of lever 28 with the frame, and the angle through which the lever moves during springing movement is α,

[71]

with one-half of α being above and below the horizontal position of the lever 28. The time necessary for the wheel to move from its highest to its lowest position is shown calculated on page 15 of the specifications in terms of L and S. In Fig. 6, there is shown a diagram illustrating the manner of solution of the vertical vibration of the spring, and the period of vibration of the cantilever spring is derived on pages 16-18. By making $T_1 = 1/2\ T_2$, the length L of the arm can be determined for a given S and leaf spring dimensions. If L is assumed, the width and depth of the spring can be determined, as stated on page 18, lines 4 and 5. By having the time-distance movements of the spring and linkage equal, no resultant forces will be present to cause residual forces that require dampening.

THE REFERENCES

The Metz patent shows a vehicle suspension which includes two links 35, 36 for each wheel. The links are substantially parallel and are pivoted to the frame bracket 28 about horizontal axes 38, 39 and to the yoke member 43 about horizontal axes 41, 42. The yoke member has arms 44 which receive king pins 46 that mount the wheel hub 57 on

which wheel spindle 61 is rotatable. Spring 14 extends transversely of the vehicle and has its central portion connected to member 13 which extends between frame members 11, 12. The bracket 82 on the yoke member has one of the outer ends of the spring connected thereto by bolt 85 and balls 87, 87' (Fig. 3). Radius arm 21 is welded to the housing member 81

[72]

of the yoke member and is pivotally connected to the frame member 22 by a ball joint in bracket 92. The king pins on each side of the vehicle are substantially on the center lines of the wheels, but the central plane of rotation of the wheels is slightly outward of the axes of the king pins to provide stability (see the parallel lines at the front of the wheel 18 in Fig. 1). Shock absorber means 102.103, etc. (Fig. 7) are provided at the inner ends of the links. It is stated on page 6, lines 42-72 that if the component parts are such as to have frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no shock absorber is needed to dampen unbalanced forces. Radius rods 21, 22 are made as long as possible in order that their frequencies of functioning will be low. It is also stated that the wheel mass and radius rod weight has a definite frequency and the spring 14 by design has an established frequency of functioning. By having the parallelogram linkage 35, 36 of a certain length a correlated frequency is established. On page 6, column 2, lines 1-6, it stated that the linkage length should be 14 to 16 inches when the radius rod is 44 to 45 inches in length in order that no undamped forces will be present. By having a rapid rate of recovery from road shocks in this design there is an increased period of road contact for the tires.

In Siebler, the independent wheel suspension includes upper link or arm 4 which is pivoted to the frame and to steering knuckle 3, and lower link 7 is also pivoted to the frame member 8 and to the steering knuckle. Leaf spring 5 extends between the spring plate 6 on the steering knuckle and

[73]

the frame member 8 which is adjustable about a transverse axis by slots 14 and screws 13 for changing the caster. The upper link acts on shock absorber 15.

The publication "Vibration Of Rail And Road Vehicles" in pages 84-86 shows differential equations being utilized for solving the equations of motion of a spring-supported weight rolling over a low spot in the road (see Fig. 66). Such terms as downward motion (y), depth of low spot (2a), and natural frequency of vibration of the weight on the spring are found in the equations.

REJECTION OF CLAIMS

Claim 1 stands finally rejected as unpatentable over Metz. The wheel 18 of Metz is connected to the frame member 11 by linkage means including arms or links 35, 36 and radius rod 21. The central portion of spring 14 is secured to the frame member 13 which joins frame members 11, 12, and the outer end of the spring is connected to yoke member 43 to which the links are pivotally connected and the radius rod rigidly connected (see bracket 82 for the spring on the housing 81 of the yoke member in Figs. 2). On page 6, col. 1, lines 42-72, it is stated that the wheel mass and radius rod have a definite frequency of functioning and the spring has an established design frequency, and by making the linkage 35, 36 of a proper length a correlated frequency is established. It would be deemed a matter of design not involving invention to proportion the spring 14 of Metz so that the frequency controlled

[74]

rate of downward movement of one of its outer ends is equal to the gravity effect rate of downward movement of the linkage and wheel mass, instead of proportioning the length of the links and radius rod to the spring.

Claim 2 stands finally rejected on the same reference as claim 1. The wheel 18 of Metz is mounted on hub 57 which has vertically extending king pins 46 thereon that are received in the yoke member. The

axis of the king pins is slightly spaced inwardly of the center plane of the wheel as stated on page 4, col. 1, lines 31-38. To have the center plane of the wheel of Metz positioned exactly in the plane of the king pins would be a matter of choice or design.

Claim 3 stands finally rejected on the same reference as claim 1. Metz establishes equivalent frequencies, and therefore the recited time and period would be equal.

Claims 4-7 stand finally rejected as unpatentable over Metz in view of Siebler and the Vibration of Rail and Road Vehicles publication. The links 36, 35 of Metz are substantially parallel and extend horizontally. Siebler teaches the use of parallelogram linkage 4, 7 and cantilever spring 5 for suspending a wheel, and therefore the radius rod 21 of Metz could be omitted without the exercise of invention. Metz makes the length of the parallelogram linkage such that a correlated frequency of functioning is established with the spring frequency and with the wheel mass and radius rod

[75]

frequency in order that no unbalanced forces will result when moving over road irregularities. It would not amount to invention to proportion the links of Metz to have natural periods of downward movement of his links equal to natural periods of downward movement of the spring when the radius rod is omitted. The proper length of the links could be found by trial and error or by mathematical formulas when proportioning the linkage to the spring. For example, the Vibration of Rail and Road Vehicle publication shows the use of equations for designing vehicle suspensions to be well-known.

Relative to applicant's remarks in his brief (on page 7, line 1 through page 8, last line and on page 10, lines 17-24) concerning the frequency of functioning of the wheel and lateral suspension links of Metz, it is believed that, although applicant and Metz utilize different terminology, each teaches the apportionment of the linkage and spring in order to obviate the need for a shock absorber and to increase the period of road contact by the tire. See page 2, column 2, lines 12-21 of Metz wherein proportionment of the parts is mentioned. In line 6 of

page 9 of applicant's brief it is stated that the Siebler reference does not show a parallelogram linkage. However, a parallelogram is mentioned on page 1, column 2, line 6 of

[76]

Siebler and the links, 4, 7 are shown as parallel in Figure 1 of the patent. It is noted that the publication, discussed on page 13, lines 5-10 of applicant's brief, is not relied upon to show specific formulas.

Respectfully submitted,

/s/ (Illegible)
Examiner, Div. 47

Atty:
Bair, Freeman & Molinare
135 S. LaSalle Street
Chicago 3, Illinois

Conf: B. Hersh

[79]

[Sept. 27, 1962, U.S. Patent Office, Board of Appeals]

Paper No. 15

Appeal No. 27-40

Hearing:
August 8, 1962

IN THE UNITED STATES PATENT OFFICE

BEFORE THE BOARD OF APPEALS

Ex parte Kenneth E. Lyman

Application for Patent filed October 5, 1959, Serial No. 844,408. Automotive Independent Wheel Suspension Systems.

Bair, Freeman and Molinare for appellant.

Before Dracopoulos and Freehof, Examiners-in-Chief and Blum, Acting Examiner-in-Chief.

Dracopoulos, Examiner-in-Chief.

This is an appeal from the final rejection of claims 1 to 7. The

Examiner has noted that the proposed amendment of December 12, 1961 to claim 3 has not been entered and that this claim will be considered in the appeal as finally rejected, rather than as it appears in the brief in amended form.

Representative claim 1:

> 1. In a vehicle suspension system including a vehicle frame, a wheel, linkage means connecting the wheel to the frame for vertical movement relative thereto and a spring acting on the linkage means urging the frame upward relative to the wheel, the improvement comprising so constructing and proportioning

> the spring that the frequency controlled rate of downward movement of the point therein which acts on the linkage is equal to the gravity effected rate of downward movement of the point in the linkage acted on by the spring.

The references relied on are:

Siebler	2,122,961	July 5, 1938
Metz	2,202,665	May 28, 1940

"Vibration of Rail and Road Vehicles," by B. S. Cain, pages 84 to 86, published in 1940.

The claims on appeal relate to a vehicle suspension system which is adequately described on pages 3 to 6 of the brief and pages 2 and 3 of the answer.

The references are sufficiently described on pages 3 to 5 of the answer.

Claims 1, 2 and 3 stand rejected as unpatentable over Metz and claims 4 to 7 as unpatentable over Metz in view of Siebler and the Vibration publication. Reference is made to pages 5 to 8 of the Examiner's Answer for his application of the references to the respective claims and his reasons in support of the rejection.

We have carefully reviewed the reference disclosures, particularly the basic reference to Metz, in the light of all the arguments presented in appellant's brief and at the oral hearing and have concluded that the

rejection of the claims for the reasons stated in the Examiner's Answer is free of reversible error.

Both the appellant and Metz are concerned with the elimination of resultant or unbalanced forces so as to obviate the necessity of using shock absorbers. As summarized in the second complete paragraph on page 7 of appellant's brief:

> "According to the Metz specification, the wheel suspension system including the wheel, the laterally extending arms and the radius rod, apart from the spring, has a definite frequency of functioning and the spring is selected to

[81]

> have the same frequency of functioning. This is explained in detail in the Metz patent on page 6, column 1, line 42 to page 6, column 2, line 16."

We are unable to draw any other meaning from the description on page 6 of Metz, starting with line 42, than the proper proportionment of the spring and the combined mass of the wheel, the laterally extending arms and the radius rod so as to have the same frequency of function, namely, so as to move together to prevent unbalanced forces. Metz specifies, "if the component parts are such as to establish frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no exterior means, such as a shock absorber, is necessary" (column 6, lines 43 to 48).

Appellant's statement in the paragraph bridging pages 7 and 8 of the brief that it appears to be Metz' intention to "consider the frequency of functioning of the wheel and the laterally extending suspension arms to be that which they would have if suspended vertically in a manner of a pendulum," does not agree with the express statement in Metz, lines 54 to 61, column 1, page 6, that the torque radius rods will each function as an entirety and with its adjacent wheel "more as a weight effect rather than as controlling the periodicity of functioning as does the pendulum in a clock mechanism". In other words, Metz considers each radius rod and the respective wheel to constitute a single mass and not to function as a pendulum.

It is our considered opinion that the wheel suspension shown by Metz and described therein inherently functions in the same manner as appellant's and that existing differences, such as the pivoting of the wheel about a vertical axis lying in the central plane of the wheel as compared with the slight offset by about 1/4 inch in Metz, are of degree only and within the

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choice of those having routine skill of the art. For these reasons and those stated in the Examiner's Answer, the rejection of the appealed claims is sustained.

The decision of the Examiner is affirmed.

/s/ Dracopoulos
Examiner-in-Chief

/s/ Freehof
Examiner-in-Chief

/s/ Blum
Examiner-in-Chief
(Acting)

BOARD OF APPEALS

[87]

[Apr. 9, 1963, U.S. Patent Office, Board of Appeals]

Appeal No. 27-40 Paper No. 17

IN THE UNITED STATES PATENT OFFICE

BEFORE THE BOARD OF APPEALS

Ex parte Kenneth E. Lyman

Application for Patent filed October 5, 1959, Serial No. 844,408. Automotive Independent Wheel Suspension System.

Bair, Freeman and Molinare for appellant.

Before Dracopoulos, and Freehof, Examiners-in-Chief and Blum, Acting Examiner-in-Chief.

Dracopoulos, Examiner-in-Chief.

ON PETITION FOR RECONSIDERATION

This is a request for reconsideration and reversal of our decision of September 27, 1962 affirming the rejection of all the claims there on appeal.

We have carefully reviewed the disclosure of the Metz patent in the light of the errors alleged in this petition but remain of the conviction that our decision is free of error. Assuming, arguendo, that Metz' scientific explanation of the invention is unsound, the fact remains that, as in the present

[88]

case, Metz proportioned his spring and the effective mass at the wheel so that downward movement of the wheel and of the spring will occur in a common period, that is, the spring and the wheel will have substantially equivalent frequencies of functioning as described by Metz on page 6, and thus eliminate resultant or unbalanced forces and obviate the necessity of shock absorbers. We remain of the view that the appealed claims are substantially met by Metz for the reasons given in our decision.

While we have reconsidered our decision, we deny the petition as to making any changes therein.

/s/ Dracopoulos
Examiner-in-Chief

/s/ Freehof
Examiner-in-Chief

BOARD OF APPEALS

/s/ Blum
Examiner-in-Chief
(Acting)

PLAINTIFF'S EXHIBIT 2

Resume:	K. E. LYMAN	
Born:	March 12, 1894	Columbus, Ohio
Education:	(formal)	
	Lewis Institute	1916 B.S.
	Univ. of Manchester	1918 ME—awarded
	Oxford	1918 D.Sc. awarded

Education: (practical)

The experiences of production development and sales (OEM) of advanced automotive components provides knowledge of factors requisite for trade acceptance. Advanced components include: duo-servo brakes, free wheeling, no-back, floating power, transmission overdrive, automatic transmission, viscosity control (avia, engines), catalyic combustion control.

With Bendix and Borg-Warner duties included:

1. Liaison with all divisions and subsidiaries on products, processes, facilities and manufacturing methods.

2. Evaluation of prospective new subsidiaries on products, facilities and personnel.

3. Clearing house on inventions and processes, including license or contact negotiation, manufacture of production units, sale to a car manufacturer and production assignment to a division or subsidiary.

Military: 1917-1919	Advanced Initiated or Effected
USA-Mem. Tech. Sect., Motor Sect., Avia. Sect. England and France	Turbo-jet design Engine catalyst

Business Experience:

1948 to present Lyman Associates

Business Experience:

1948 to present	Lyman Associates	Catalytic combustion control Electronic fuel injection Electronic combustion control

		Thermit combustion control Suspension System Torque dividing differential
1946 to 1948	Tucker Corporation Technical Counsel to Preston Tucker, Pres.	Majority of advertised advances
1939 to 1946	Physical & Chemical Corp. President	Catalytic combustion control
1929 to 1939	Borg-Warner Corp. Technical Assistant to C. S. Davis, Pres.	Free wheeling Floating power Transmission overdrive Automatic Transmission Suspension System Disc brakes Viscosity control
1924 to 1929	Bendix Corporation Technical Assistant to Vincent Bendix, President	No back Duo-servo brake Automatic Transmission
1922 to 1924	DePaul University and Academy Professor of Engineering	
1919 to 1922	Currey Lyman Steam Automobile Co. Engineer	Modulated Combustion

Prior experience includes: Studebaker—Mechanical Service; Mitchell Motors—Technical Service; Doble—Experimental Engineer; Cadillac Motor Car Company—Draftsman and Experimental Laboratory.

Contracts have been negotiated with the Armed Services. About 870 patent applications have been filed.

JA 43

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 1

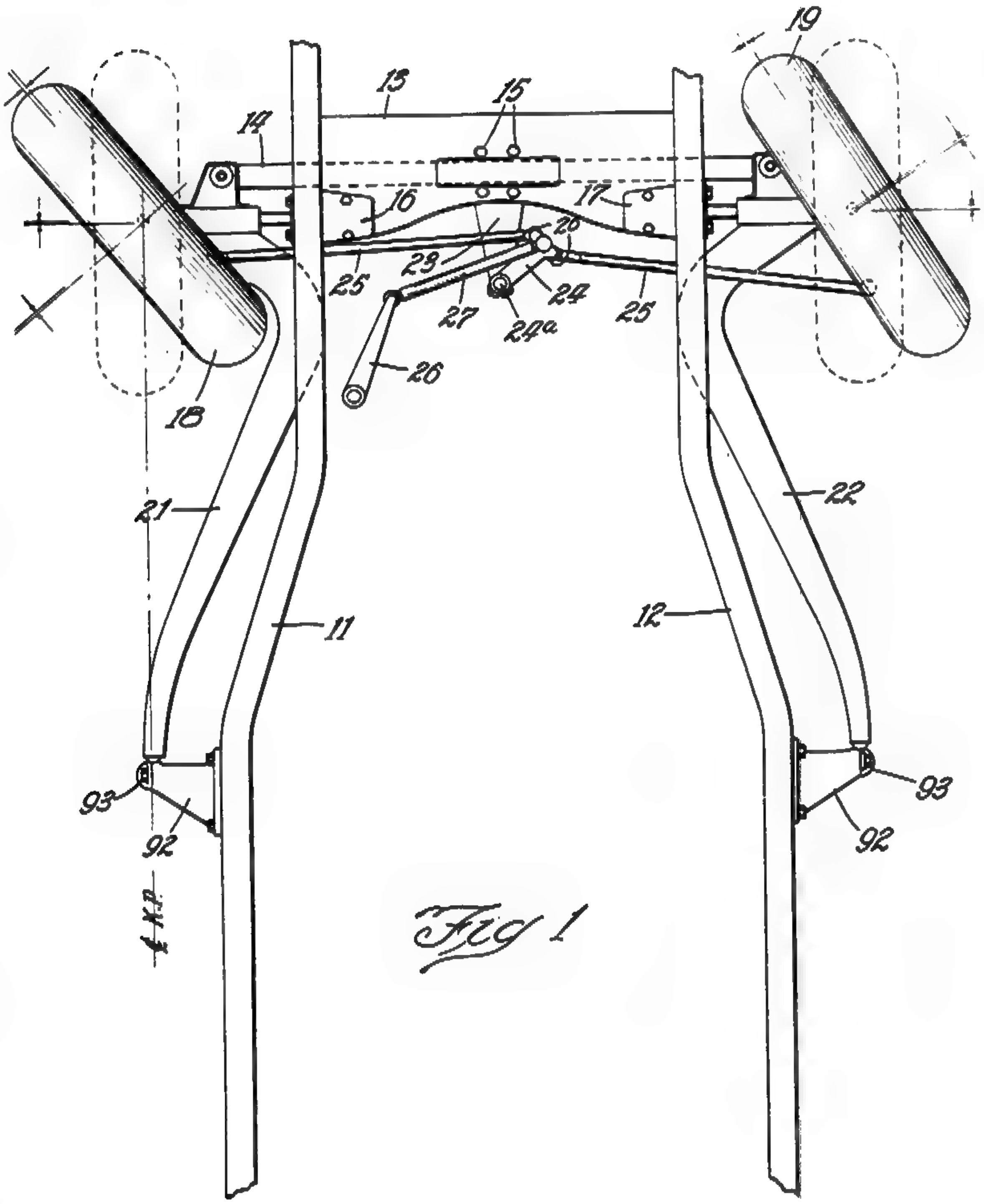


Fig 1

Inventor:
Anthony J. Metz, Sr.
By John W. Hinton
Atty.

JA 44

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 2

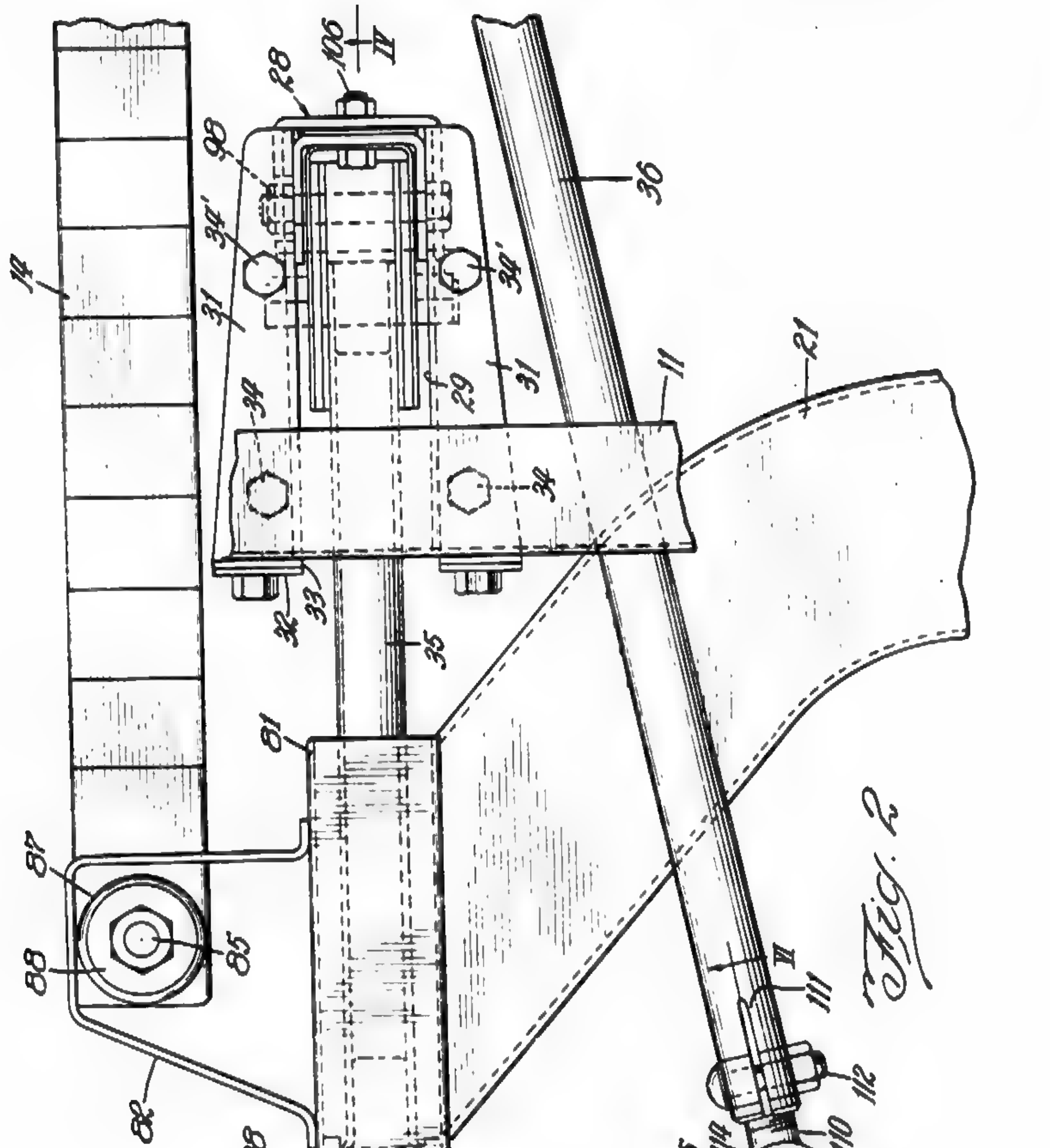


Fig. 2

Inventor
Anthony J. Metz Sr.
By John W. Watson
Atty.

JA 45

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 3

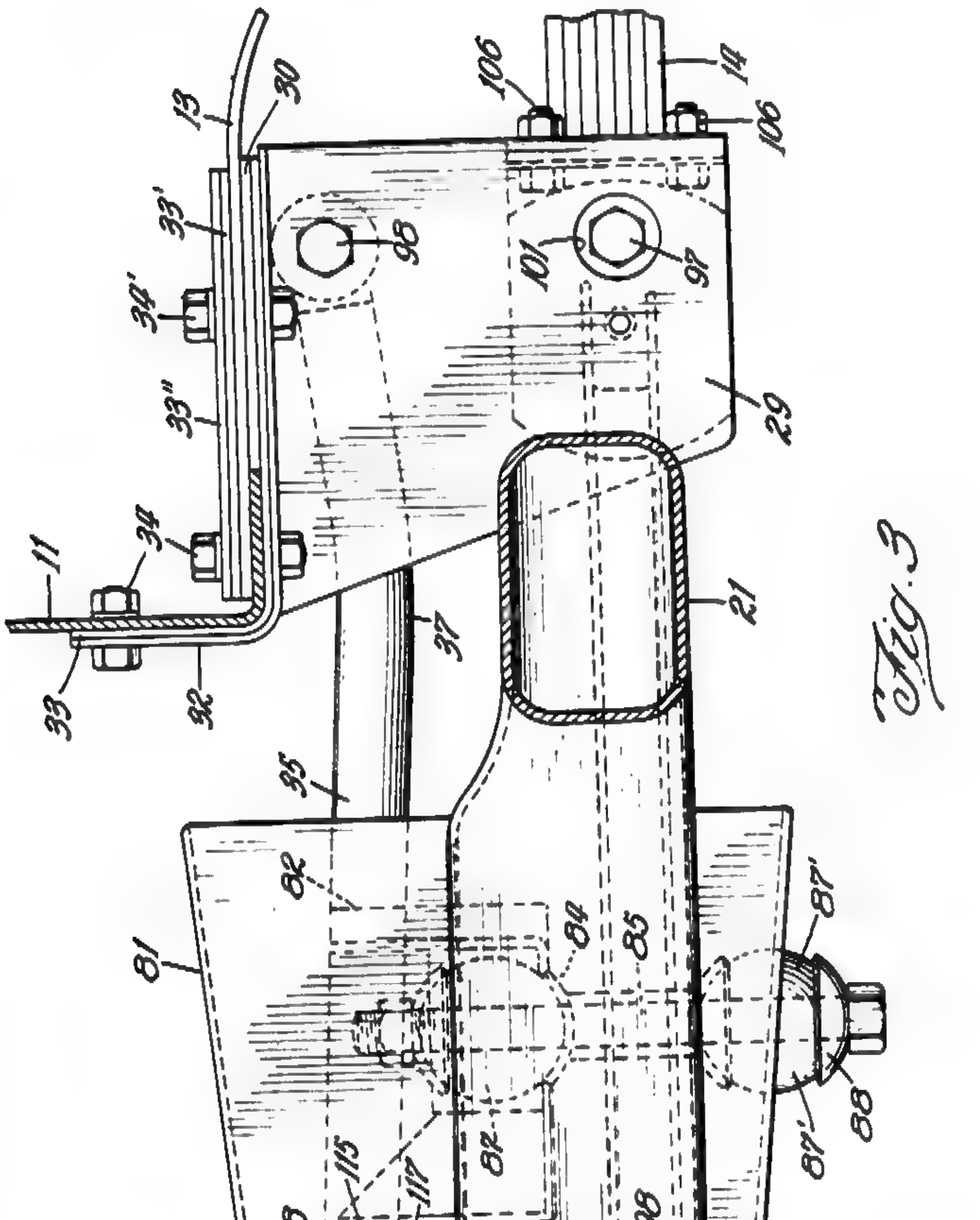


Fig. 3

Inventor
Anthony J. Metz Sr.
By John A. [illegible]
Att'y

JA 46

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 4

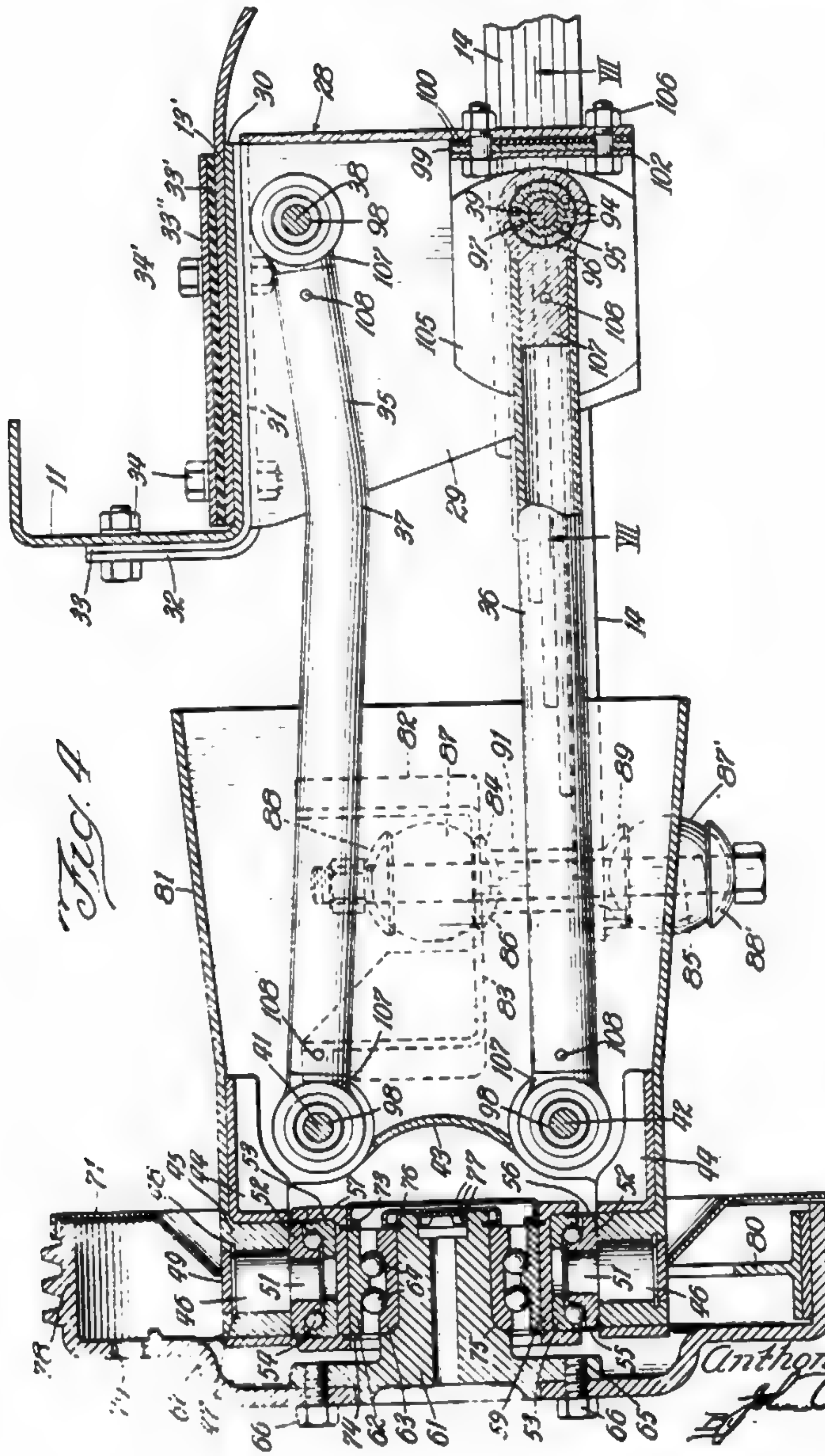


Fig. 4

Inventor
Anthony J Metz Sr.
Att'y.

JA 47

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 5

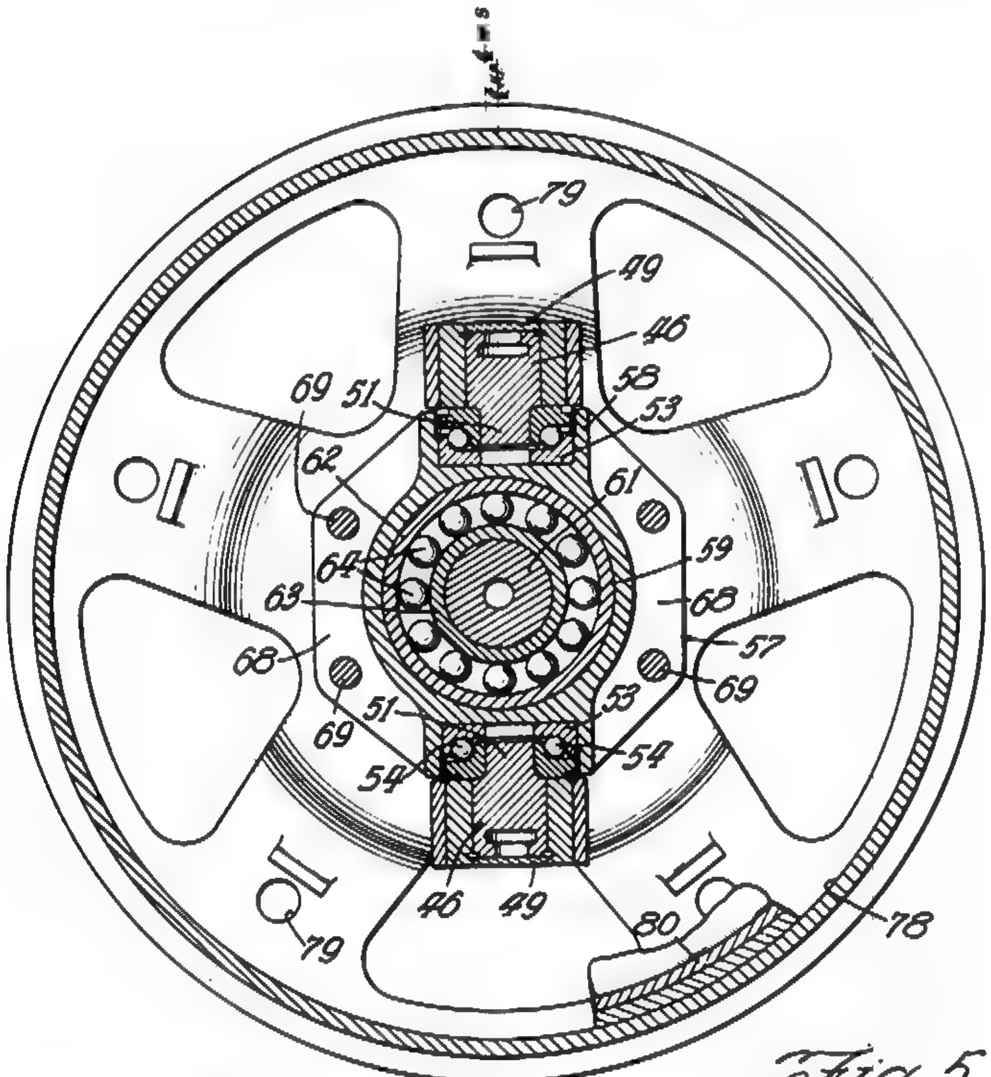


Fig. 5

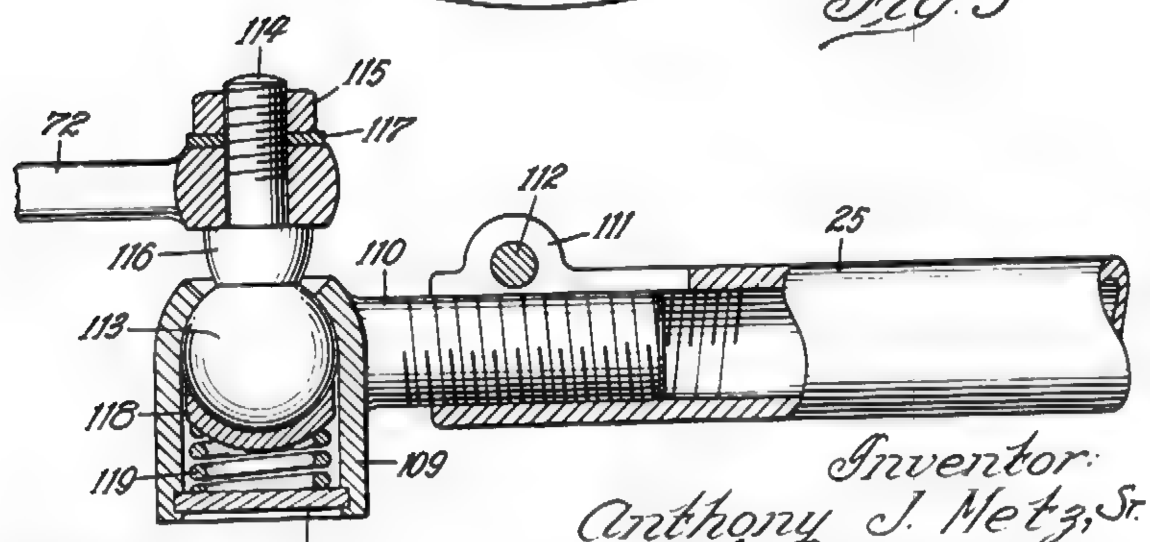


Fig. 6

Inventor:
Anthony J. Metz, Sr.
By: John W. [illegible] Atty

JA 48

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 6

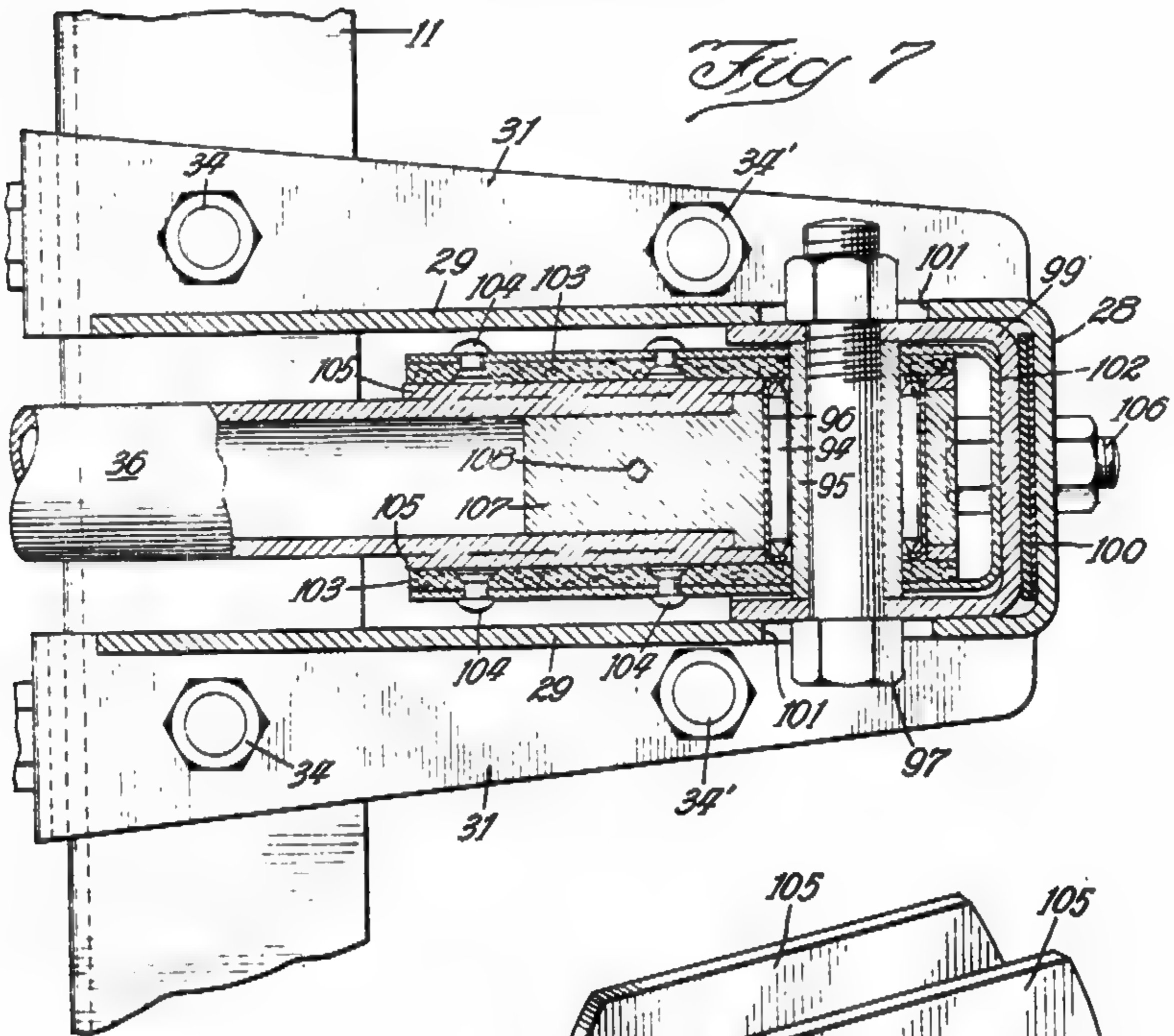


Fig 7

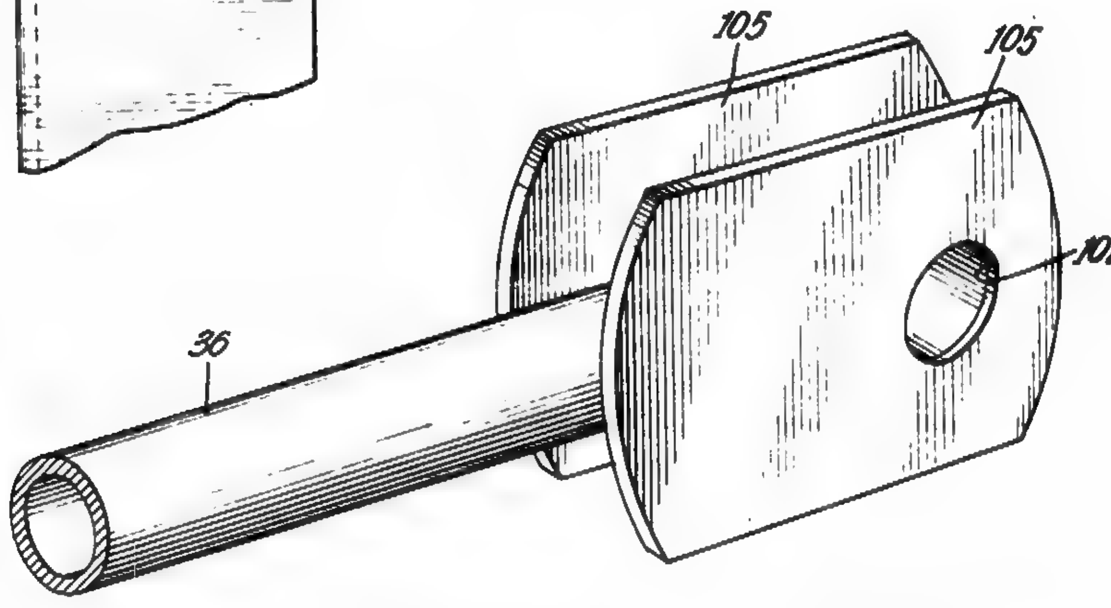


Fig. 8

Inventor:
Anthony J. Metz, Sr.
By: John A. Watson
Atty.

JA 49

May 28, 1940. A. J. METZ, SR 2,202,665

MOTOR VEHICLE CONSTRUCTION

Filed March 22, 1938 7 Sheets-Sheet 7

Fig. 9

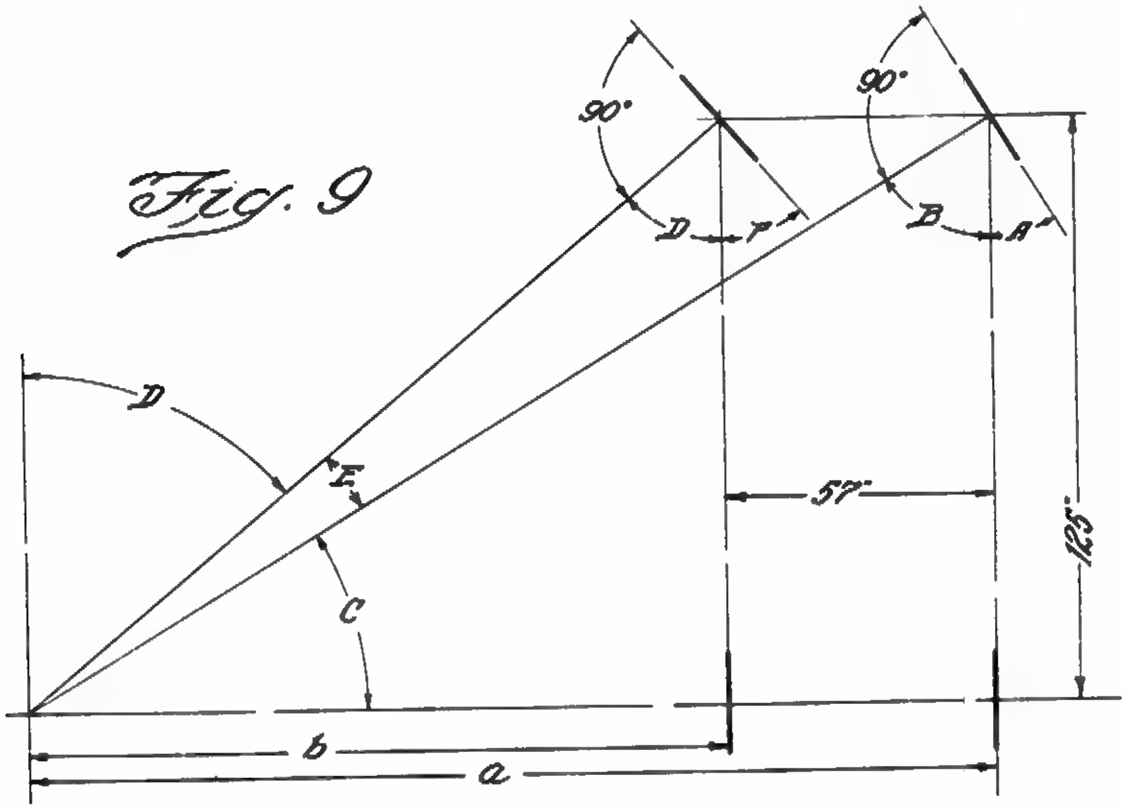
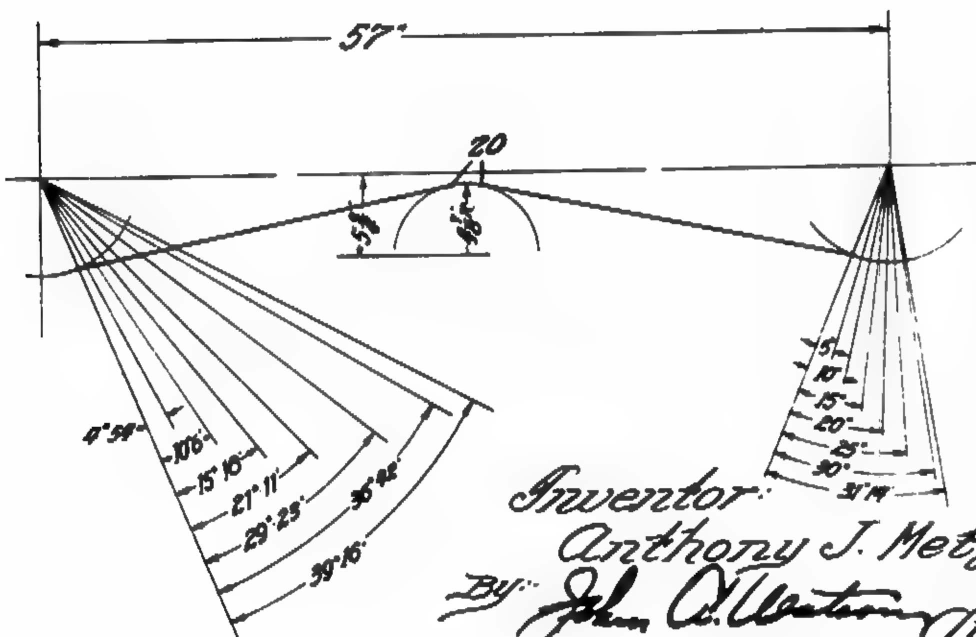


Fig. 10



Inventor:
Anthony J. Metz, Sr.
By: John A. Weston Atty.

UNITED STATES PATENT OFFICE

2,202,665

MOTOR VEHICLE CONSTRUCTION

Anthony J. Metz, Sr., Davenport, Iowa

Application March 22, 1938, Serial No. 197,441

22 Claims. (Cl. 280—96.2)

This invention relates primarily to the construction of the steering or dirigible end of automotive and other vehicles and, more particularly, to the wheel mounting and securing arrangements, to the spring mounting and suspension, and to the steering mechanism and the connections thereof between the fixed portions of such mechanism, such as the steering column and pitman, and the dirigible wheels and related parts. In certain aspects the invention is related to and includes features of improvement upon and certain features generic to the invention or inventions disclosed in my copending application Serial Number 140,463, filed May 3, 1937. Certain features of the invention are as applicable to non-dirigible wheels as to dirigible wheels, as will become apparent.

The ordinary design of automotive vehicle front ends, that is, the dirigible or steering parts, whether front or rear ends, is a complicated and tedious task owing to the multitude of variable factors which must be taken into account and most, if not all, of which are more or less mutually interdependent to the extent that variations in any one factor may affect all of the other factors. In the so-called Ackerman principle of steering or arrangement of front axle or end construction as improved and now commonly used, the front wheels are mounted on individual pivots called king pins but are connected by a tie rod and to the steering wheel through the steering column, in such manner as will permit the wheels to be moved or steered together in order to turn the vehicle. In order to attempt to keep the wheels running true with respect to the center of the turning circle, the Ackerman principle requires that the spindle arms, which connect the tie rods and wheels, be set obliquely inward from the wheels, and the angles and distances must be fixed with a precision not always observed. Each wheel is also given caster, camber and toe-in.

Caster, of course, is used to throw the center of road contact of the wheel behind the effective center of pivoting or swinging of the wheel in turning the vehicle, while the wheel is given camber to bring the center of road contact of the wheel as nearly directly under the point of wheel pivot (king pin) loading as is reasonably possible, and toe-in is used cooperatively to correct for camber and caster effects, for control over road conditions and to produce stability of direction and control under normal operation. Each of these factors may exert a definite influence upon each of the others and all play an important part in the steering of the ordinary vehicle.

The complications attendant upon the introduction of the factors of caster, camber and toe-in have been appreciated for a long time but efforts to avoid them have been more or less unsuccessful. When there is too much caster the wheels are difficult to turn from a straight path and when there is too little caster there may be weaving and wandering or shimmy. If the camber is too much, too little or unequal as between the wheels the tires are worn unevenly and undesirably, and steering difficulties are encountered, and, if the toe-in is not correct similar troubles ensue. The problems have not been simplified but rather have been rendered more and more complex with the introduction of larger tires with less air pressures, the advent of independently sprung wheels, both of which look primarily to the comfort rather than the safety of the vehicle occupants, and the use of higher and higher vehicular speeds. Safety factors, particularly those dependent upon the human equation, the vehicle driver, have not kept pace with those problems.

Among the steering problems is that of turning radius, fundamentally that angle in the steering geometry which holds each front wheel tangent to the circle on which it should travel in making a turn. Since the front axle is not mounted on a center pivot and the front wheels do not turn with the axle, as in a wagon, but are independently pivoted on king pins or the like, in order to maintain the wheel axle axes coincident with radii of the turning circle, the wheels must be turned at differential rates so that the inside wheel, on the turn, will swing through a greater angle for each given increment of angular movement of the outside wheel, thereby to maintain the proper turning radius. This problem is affected by each of the factors of camber, caster, and toe-in and, in turn affects those factors, so that each factor may be said to be more or less inextricably dependent upon each of the other factors in the ordinary design.

The complexity of front end design is further complicated by the spring design and suspension, by tire construction and inflation and by other factors and conditions as will be appreciated. The character of the spring, its location and points of connection may vitally affect the steering particularly under operating conditions. When one of the wheels strikes an obstruction or a depression in the road, the deflection of the spring may permit a considerable momentary

change in the camber and toe-in or may even (temporarily at least) create an unsafe condition including undue driver fatigue. Weakened or weakening springs as well as shifting springs, wear in king pins and shackles and other parts, bent or displaced axles, and various other troublesome conditions, a large part of which may be attributed to the complexity of present designs of dirigible front ends, also play their part in affecting the steering through changes in camber, caster, and toe-in and other factors.

Among the numerous factors to be considered in designing the dirigible parts such as the front end of an automobile are a number heretofore disregarded or neglected. When, for instance, a member and its point of reception of forces are so designed and located that stressing forces encountered may operate with an effective leverage or leverages, the loading or stresses on the member and other members associated with it are multiplied, and, perhaps, differ directionally from the direction of the initial forces. There must be compensation for these leverage effects otherwise they would be transmitted to various parts of the front end including the steering mechanism and would seriously affect the steering and general roadability of the car. And in ordinary designs compensation is provided to a small extent initially by tight bearings and other connections, by high steering ratios and by the provision of the usual shock absorbers, etc., which decrease the roadability of the car, but when wear occurs, even this small compensation is lost. The correct solution to the problem, however, lies largely in the elimination of the effective leverages or in the reduction of those leverages to as near zero values as possible.

Other forces commonly overlooked are those forces which arise through unbalanced rotating parts or through the application of unbalanced forces to rotating parts. For example, when a tire or a wheel is out of balance (dynamic or static) or when the brake drum is so located that its reaction effects work at a leverage angle, the forces resulting therefrom create a condition where the wheel alignment and roadability may be considerably affected. In the case of a brake drum location of such character, an application of the brakes may cause the vehicle to 'duck' to one side or the other, and may cause or tend to cause wheel 'tramp' or 'shimmy' as well as produce other undesirable results. These various force-leverage effects are quite unsatisfactory from the standpoint of driver comfort as well as from the aspect of safety.

Consequently, one of the primary objects of this invention is to minimize the problem of design of a vehicle front end construction in such ways and to such extent as will eliminate elaborate and expensive engineering calculations and construction, as will effect substantial economies in labor and material in manufacture and maintenance, as will provide increased strength or safety factors regardless of decrease in materials, parts, weight and labor, as will reduce road hazards, as will reduce or eliminate tire scuffing, cupping and other forms of wear, as will give easier steering with the elimination of practically all road shock, road tramp, shimmy, weaving or wandering, and, in short, as will improve and simplify the design, construction, operation and maintenance of a vehicle to a substantial degree.

Another important object is to provide a construction for the mounting, suspension and steering of the dirigible wheels of a vehicle wherein the moments of forces reacting against the wheel and through its mounting and suspension against and through the steering mechanism to the steering column and steering wheel, are resolved in such a manner as to bring them substantially to zero, with the result that such effects as wheel shimmy, tramp, pull, weaving and so forth are inhibited or cannot develop and with the further result that steering may be made easier as by reduction of the steering ratio to a lower ratio than with ordinary designs.

Another object is to provide a design wherein the ratio, proportions and arrangements of the parts is such that the reactive effects of weight mass, inertia force and the forces of resilient supporting means are self absorbing in the system to the end that no shock absorber action is necessary except when the velocity of the inertia forces in a vertical direction is relatively different from the velocity of the forces of the resilient supporting means.

Another object is to arrange, construct and mount the radius torque rods so that each may function at relatively low frequency and substantially as a mass, and so that in combination with the parallelogram linkage of the wheel mounting which has a relatively higher frequency and with the wheels themselves, a relationship is established which tends toward minimum displacement of the vehicle mass under rough or uneven road conditions. In this connection it may be noted that the invention contemplates the provision of radius torque rods of great length and located in a novel manner.

Another object is to provide a construction for the dirigible wheels of a vehicle wherein the wheels have an optimum amount of caster but wherein camber is rendered wholy unnecessary and toe-in is reduced substantially to zero.

Still another object is to provide a construction whereby the mean plane of rotation of each wheel is at all times perpendicular to the normal or mean horizontal plane of, say, the frame of the vehicle, even as the wheels rise and fall under varying loading or under varying road surface conditions, thereby to eliminate undesirable gyroscopic effects commonly encountered in most of the present designs.

A further object is to provide a steering mechanism whereby the wheel at the inside of any given turn will swing about its vertical pivot axis through arcs increasingly greater than the arcs through which the wheel at the outside of the turn swings so that the plane of rotation of each wheel will constantly lie tangent to the circle on which such wheel should run in making the turn and so that projections of the axes of rotation of the front wheels will at all times intersect one another substantially on a projection of the common axis of the rear wheels or, will intersect a line perpendicular to and intersecting a projection of the common axis of the rear wheels and perpendicular to a generally horizontal plane such as the mean plane of the vehicle frame.

Further objects are to provide simple and economical constructions by and through which the foregoing and other objects may be attained, the constructions including a special form and arrangement of floating wheel and wheel mounting, a special wheel spindle and turning pivot arrangement, a special spring suspension and mounting, special shock absorbing or damping devices, special steering mechanism, a special torque or radius arm, and various other important

features mutually contributing to the desired results and ends to be reached.

Many other objects as well as the advantages and uses of the invention will become apparent and will be understood by those skilled in the art after reading the following description and claims and after viewing the drawings in which:

Fig. 1 is a top plan view, somewhat schematic in character, of the front or dirigible end of the chassis of an automobile, showing a preferred form of the invention applied thereto; the engine and other mechanism being omitted for the sake of simplification.

Fig. 2 is a top plan view on a larger scale than the scale of Fig. 1, of the upper left hand corner portion of the mechanism illustrated in Fig. 1.

Fig. 3 is a rear elevation of the mechanism shown in Fig. 2 and to the scale of the latter.

Fig. 4 is a view with some parts in vertical section taken along the section line IV—IV of Fig. 2 looking forward, and on the same scale as Figs. 2 and 3.

Fig. 5 is a section taken substantially along the line V—V of Fig. 2 and on the scale thereof.

Fig. 6 is a vertical section of details of connection between a tie-rod and a spindle arm, taken substantially along section line VI—VI of Fig. 2 but on a larger scale.

Fig. 7 is a horizontal section looking upward, taken substantially along the line VII—VII of Fig. 4, showing the details of construction of a damping mechanism or shock absorber, the scale being greater than that of Fig. 4.

Fig. 8 is a perspective view of one of the parallel arms of a wheel carrier structure showing part of one of the shock absorbing or motion damping mechanisms, and

Figs. 9 and 10 are diagrammatic illustrations of the manner in which an automobile equipped with the invention may be steered.

The portion of the chassis and running and steering gear shown in Fig. 1 includes longitudinally extending channel frame members 11 and 12 joined at their front end portions by a transverse member 13, a semi-elliptical spring 14 carried by a saddle member (not shown) attached to frame member 13 by U-bolts 15, wheel carrier means generally designated 16 and 17, wheels 18 and 19, radius rods 21 and 22, a rearwardly extending bracket 23, forming part of the spring saddle and carrying a swinging arm 24 pivoted thereto at 24a, tie rods 25 connected between the wheels 18 and 19 and arm 24, a pitman 26, and a drag link 27 connecting the pitman and arm 24. The construction and arrangement of the steering mechanism, insofar as the spindle arms, tie rods, pivot arm 24, bracket 23, drag link and locations of pivot connections between them are concerned, are so similar to the steering mechanism disclosed in said copending application that they may be considered identical. In the construction of the embodiment of the invention illustrated no axle as such is utilized, the parts referred to as the wheel carrier means 16 and 17 together with other mechanism and members serving the purposes of an axle as well as performing other functions. Each wheel carrier means is similar to the other, for which reason a description of either will suffice for both although there are certain relationships between them as will appear. The left front wheel carrier and its associated mechanisms have been illustrated and will be described, in detail.

Referring for the moment to Figs. 2, 3, 4 and 7, it will be noted that a generally U shaped bracket 28, the arms of which are formed as relatively deep vertically extending flanges 29, with relatively narrow horizontal flanges 31, has the ends of its arms formed or bent at right angles to the flanges 31 to provide portions 32 which lie against the outer face of the bottom of channel frame member 11. A sheet of rubber or other insulating material 33, may be disposed between the flanges 31 and 32 of the bracket, while bolts 34 secure the bracket 28 to the channel member. A steel filler sheet 30 is disposed between the flanges 31 and a rearwardly extending flange 13' on the transverse member 13, a sheet of rubber or other resilient material 33' overlies the flange 13', and a steel cap plate 33'' is superposed on the rubber and all are held together by the bolts 34 and 34'.

Pivotally supported by the bracket 28 and between the vertically depending flanges 29 thereof are a pair of arms 35 and 36, the upper of which is bent slightly at 37, for the purpose of permitting the same to swing upwardly through its maximum required distance without interference with the channel frame member. The arms 35 and 36 are substantially parallel and are pivoted on pivots, the axes 38 and 39 of which are perpendicular to a vertical plane, extending transversely of the vehicle. At their opposite ends the arms are pivotally connected by pivots, the axes 41 and 42 of which are parallel to one another and to the axes 38 and 39, to a yoke member 43. The pivot axes 41 and 42 are spaced apart substantially the same distance that the axes 38 and 39 are spaced apart, and extend parallel therewith, so that a plane containing the axes 41 and 42, when the arms are in any selected position, will lie parallel to all other planes containing the axes 41 and 42 as the arms 35, 36, swing up and down in a vertical plane to different positions.

The yoke member 43 has forked arms 44, each of which carries a fixed bushing 45, within which a king or trunnion pin is disposed and fixed and held against displacement by a snap ring 47 engaged in an undercut slot 48 in the bushing, while a welch plug 49, may be used to close the outer end of the bushing. Each king or trunnion pin 46 has a reduced inner end portion 51, on which one race member 52 of a bearing is mounted, the other race member 53 being carried by a part of the wheel hub structure. Balls 54 roll in the races and the bearings are of the sealed-lubricant type closed by sheet metal rings 55 and 56. A wheel hub member of cast steel 57, the formation of which is best illustrated in Fig. 5, is provided with vertically spaced wells or recesses, the walls of which are designated 58, within which the bearing members 53 are disposed, and it has a transversely extending central cylindrical portion 59, within which the wheel spindle 61, and the wheel spindle bearings, including outer race 62, inner race 63, and balls 64, are carried. The wheel spindle has a shouldered flange 65, which is drilled and tapped at suitable places for the reception of stud bolts 66, with which the brake drum member 67 is attached to the spindle. The hub member 57 also carries forwardly and rearwardly extending flanges 68, which are suitably drilled and tapped for the reception of bolts 69, by which a drum backing plate 71 is secured thereto. A spindle arm 72 is also secured to the casting 57 by the rearwardly extending flange 68 thereof and by means of one pair of the bolts 69.

The spindle bearing race member 62 is held in place in the hub member 57 by wedging snap rings 73 and 74, which engage in circumferential

recesses or grooves provided in the casting 57 and press against the ends of the race member. The wheel spindle 61 has a circumferential shoulder 75, against which one end of race member 63 abuts and which positions the spindle with respect to the spindle bearing, while a wedging snap ring 76, engaged in a circumferential recess or groove formed in the inner end of the spindle and pressing against race member 63, serves to secure the spindle within the bearing with the bearing race member 63, abutted against the shoulder 75. Dust caps 77 of sheet metal and having a friction fit with the respective parts with which they are shown to be engaged, may be utilized to protect the spindle bearing.

While the wheel has a certain amount of caster, as will be described, it has no initial camber or toe-in. The king or trunnion pins 46 have a common axis which lies in a vertical plane which may be parallel to the planes containing the pivot axes 38, 39, and 41, 42, and this common axis is also perpendicular to the normal horizontal plane of the vehicle chassis. The axis of the spindle 61 and spindle bearings is perpendicular to the vertical planes containing the pivot axes 38, 39 and 41, 42, but lies slightly rearward (about ⅛" in a full size construction) of the common axis of the king or trunnion pins, as indicated by the legends designating the center line of the spindle and center line of the trunnions on Figs. 2 and 5 of the drawings. The mean plane of rotation of the wheel, as indicated by the legend "C wheel" in Fig. 2 is disposed slightly outward of (about ¼" in the full size construction mentioned, supra) and parallel to a longitudinally extending plane containing the common axis of the king pins or trunnions when the wheel is running straight ahead, while the flange 78 of the brake drum extends substantially equal distances to each side of the said plane containing the common axis of the king pins thereby balancing the braking efforts and preventing the wheel from 'ducking' to one side or the other. The wheel proper, of course, may be attached to the brake drum member 67 by means of bolts which pass through the wheel spoke or disc structure into suitably disposed and tapped openings 79 formed in the drum member 67. The disposition of the axis of the wheel spindle rearwardly of the common axis of the king or trunnion pins is sufficient to provide the necessary caster, and the disposition of the center of tread or central plane of rotation of the wheel slightly outward of a parallel longitudinal plane containing the common axis of the king or trunnion pins produces or tends to produce a certain stability, as will be understood by those skilled in the art. While a brake shoe 80 with its attached lining are shown in Figs. 4 and 5, no attempt has been made to illustrate any other parts of the wheel brake mechanism which form no part of the present invention.

The yoke member 43 is rigidly and more or less integrally connected, as by welding, with a box skirt or housing member 81 the walls of which are spaced sufficiently far from the parallel link arms 35 and 36 as to avoid them during maximum relative vertical movements, but close enough to afford a certain amount of protection to the parts surrounded. However member 81 serves other functions, for, among other things, it supports a forwardly extending bracket 82 upon and to which one end of spring 14 is seated and secured, and it serves as an anchorage or abutment for the forward end of the torque, thrust or radius rod 21, the member 81 and rod 21 being welded or otherwise rigidly and, in effect, integrally secured together.

The bracket 82 which may also be welded to member 81, has a bottom wall 83 which is apertured as at 84 for passage of an anchor bolt 85. Portions of the wall 83 are depressed as at 86 around the aperture or slot 84 to provide a spherical seat for a resilient (rubber or composition) ball 87 which surrounds the upper portion of the stem of bolt 85 and is capped by a metal cap 88. The lower end of the bolt 85 passes through an aperture in the end of the spring 14 and like the upper end is equipped with a resilient ball 87' held between a metal cap 88' and a spherical socket 89 seated against the spring leaf at the bolt aperture or within the aperture. A spacer bushing 91 serves to hold the spring and bracket wall 83 in proper relationship. As will be appreciated, the spring may be secured to member 81 in other ways although the arrangement shown and described has been found to be desirable in actual constructions.

The radius or torque rod or arm 21 is of box section and may be formed of relatively heavy gauge sheet steel bent to box section and welded. It may be formed integral with the skirt or housing member 81, rather than separately therefrom and welded thereto. In longitudinal side elevation it may be straight dipping slightly to clear the adjacent tie-rod although the section decreases in all overall dimensions to its rear end at which place it may be equipped with a ball (not shown) to make, substantially, a universal joint with a socket formed in a bracket 92 and a cap 93. The bracket 92 may be secured to one of the longitudinal frame members 11 and 12 as indicated in Fig. 1. It will be noted that each of the radius rods at its front end extends over a substantial transverse area which includes areas closely adjacent to the pivots 41 and 42, to the common axes of the trunnions and to the center of the wheel spindle bearing, and that it is disposed almost directly rearward of the spring connection with the brackets 82. In longitudinal plan each radius rod is curved inwardly of the chassis for a short distance at its front end to provide clearance for the front wheels as they are turned in steering, but returns outward and rearward to the ball and socket joint with the brackets 92 on frame member 11 or 12. Preferably the center of the ball and socket joint between a radius rod and a bracket 92 lies substantially in longitudinal alignment in plan with the center line or axis of the trunnions and substantially in longitudinal alignment in elevation with the center of the wheel spindle and bearing under normal conditions. The radius rods should be of substantial length as indicated in the drawings and in no event should be less than twice and, preferably, thrice the mean length of the parallel arms or links 35, 36 between the pivot centers thereof. In practice the radius rods should be just as long as is commercially expedient.

Each of the parallel arm pivots of which the axes are numbered 38, 39, 41, and 42, is preferably constructed with needle bearings as represented in the lower right hand portion of Fig. 4, wherein needles 94 are disposed between hardened spaced bearing sleeves or bushings 95 and 96. The sleeves 95 surround pivot bolts 97 and 98 and serve as spacers as will be understood; however the bolts 97 pass through the arms of a yoke member 99 and through enlarged apertures or

tion and by way of example only and is not to be considered as limiting the invention which may assume various embodiments within its purview and the scope of the following claims.

I claim:

1. In a vehicle front end construction in combination, a frame member, a pair of substantially parallel arms pivotally connected at one end of each with said frame member on pivot axes spaced apart in a substantially vertical plane extending longitudinally of the vehicle, a rotatable wheel member, a hub member, a substantially horizontal spindle carried by said wheel member and disposed in said hub member, bearings between said hub member and spindle for the rotation of said spindle about its axis, a rearwardly extending radius rod, a pair of vertically spaced and coaxial trunnions, means carrying said trunnions and relatively rigid with said radius rod said trunnions being associated with said hub member radially outward of said bearings for oscillation of said wheel member about the axes of the trunnions, and means pivotally connecting the other ends of said parallel arms with said trunnion carrying means on pivot axes spaced apart in a plane substantially parallel to the plane containing the pivot axes of the first said ends of the arms.

2. In a vehicle front end construction in combination, a frame member, a pair of substantially parallel arms pivotally connected at one end of each with said frame member on pivot axes spaced apart in a substantially vertical plane extending longitudinally of the vehicle, a rotatable wheel member, a substantially horizontal spindle carried by said member, a hub member, bearings between hub member and spindle for the rotation of said spindle about its axis, a longitudinally extending radius rod, means carrying a pair of vertically spaced and coaxial trunnions, said trunnion carrying means being relatively rigidly associated with said radius rod and also associated with said hub member radially outward of said bearings for oscillation of said wheel member about the axes of the trunnions, means pivotally connecting the other ends of said parallel arms with said trunnion carrying means on pivot axes spaced apart in a plane substantially parallel to the plane containing the pivot axes of the first said ends of the arms, and motion damping means including a portion carried by one of said parallel arms.

3. In a vehicle front end construction in combination, a frame member, a pair of substantially parallel arms pivotally connected at one end of each with said frame member on pivot axes spaced apart in a substantially vertical plane extending longitudinally of the vehicle, a rotatable wheel member, a hub member, a substantially horizontal spindle secured to said wheel member and disposed in said hub member, bearings between said hub and spindle members for the rotation of said spindle about its axis, a longitudinally extending radius rod, means rigidly secured to said radius rod and carrying a pair of vertically spaced and coaxial trunnions, said trunnions being associated with said hub member radially outward of said bearings for oscillation of said wheel member about the axes of the trunnions, means pivotally connecting the other ends of said parallel arms to said trunnion carrying means on pivot axes spaced apart in a plane substantially parallel to the plane containing the pivot axes of the first said ends of the arms, and motion damping means operatively associated with the frame and the frame connected end portion of one of said parallel arms.

4. In a dirigible wheel assembly for a vehicle, a frame, a pair of substantially parallel arms of substantially equal length extending substantially transversely of the vehicle and pivotally connected at one end of each with said frame for swinging movements in a substantially vertical plane, means pivotally connecting the other ends of said arms in spaced relation for relative movements therebetween in a substantially vertical plane, a pair of vertically spaced trunnions carried by said connecting means, the axes of said trunnions being substantially coaxial with one another and being perpendicular to a horizontal plane, a hub member mounted between said trunnions for pivotal movements thereon and with respect thereto, a wheel spindle rotatably disposed in said hub member between said trunnions, said spindle having a horizontal axis located rearwardly of the line of axes of the trunnions, and a rod secured to said connecting means and extending rearward therefrom substantially parallel to the longitudinal axis of the frame, said rod being so constructed and disposed as to resolve forces applied at the front end thereof into forces thrusting rearwardly parallel to said frame.

5. In a dirigible wheel assembly for a vehicle, a frame member, a pair of substantially parallel arms of substantially equal length extending substantially transversely of the vehicle and pivotally connected at one end of each with said frame member for swinging movements in a substantially vertical plane, a pair of vertically spaced trunnions, means pivotally connecting the other ends of said arms in spaced relation with said trunnions for relative movements therebetween in a substantially vertical plane, the axes of said trunnions being substantially coaxial with one another and being perpendicular to a horizontal plane, a wheel spindle rotatably disposed between said trunnions, said spindle having a horizontal axis located rearwardly of the line of axes of the trunnions, and a radius rod connected at one end to the said means and at its other end to said frame at a place substantially in line with the center of rearwardly thrusting forces which may be exerted against said spindle.

6. In a dirigible wheel asembly for a vehicle, a frame, wheel locating means at each side of said frame, each locating means comprising, a pair of relatively nonresilient and substantially parallel arms of substantially equal length extending substantially transversely of the vehicle and pivotally connected at one end of each with said frame for swinging movements in a substantially vertical plane, a pair of vertically spaced trunnions, means pivotally connecting the other ends of said arms in spaced relation with said trunnions for relative movements therebetween in a substantially vertical plane, the axes of said trunnions being substantially coaxial with one another and being perpendicular to a horizontal plane, a wheel member including a spindle rotatably disposed between said trunnions, said spindle having a horizontal axis located rearwardly of the line of axes of the trunnions, a bracket non-rotatably carried by each locating means adjacent to its wheel member and forward of the line of spindle axes, and a spring secured at a center portion to said frame and at its ends to said brackets.

7. In a dirigible wheel assembly for a vehicle, a frame, wheel locating means at each side of

drop while the vehicle body and other parts because of inertia and other effects tend to continue at the same level but each wheel, in dropping, will continue in planes of rotation which are parallel to its previous plane of rotation and parallel to one another. This action of course follows from the action of the parallel arms or links 35 and 36. Similarly the wheels rise on striking an abrupt rise in a road surface, maintaining parallel planes of rotation.

Owing to the fact that the common axis of the trunnions or king pins is practically centered with respect to the central or mean plane of rotation of the wheel, being offset inwardly by about ¼ of an inch in the embodiment mentioned, and to the fact that the trunnion axes are substantially perpendicular at all times to a normal or mean horizontal plane of the vehicle, braking forces and forces against the wheel in its course of travel are carried directly rearward and absorbed or dissipated with little transmission to the steering wheel, and the gyroscopic forces of the rotating parts do not fight against the steering mechanism. Not only are such forces received at zero or substantially zero leverages but the elimination of stub axles and connections between the links 35 and 36 with the trunnion carrying member and between the spring end and the pivot axes 41 and 42, and the location and arrangement of the radius rod, on each side of the vehicle, reduce the ordinary bearing loadings to a point where the steering ratios may be cut substantially in half for the same control effort. Furthermore the composite construction gives a relatively high control safety factor since most of the forces produced are absorbed without entering the steering linkage so that, as in actual tests, a tire may be driven on while flat or may blow or the car may be driven over a high curb or the like, at high speed without relative danger.

In the design of a construction for independently mounting vehicle wheels, if the component parts are such as to establish frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no exterior means, such as a shock absorber, is necessary as a component part of the mechanism because the function of the shock absorber is to bring to rest unbalanced or undamped forces which are incident to the operation of an unbalanced mechanism. This relation of parts in the present embodiment of the invention is established by making the torque radius rods or longitudinal control members as long as possible so that the frequency of functioning of such members will be as low as possible, and so that each will function as an entirety and with its adjacent wheel, more as a weight effect rather than as controlling the periodicity of functioning as does a pendulum in a clock mechanism.

This wheel mass and that portion of the weight of the torque radius rod which may be considered a part of the wheel mass has a definite frequency which is a matter related to mass, tire size and amount of air pressure of the tire, and the car spring also, by design, has an established frequency of functioning similar to a tuning fork. By making the length of the parallelogram linkage (35 and 36) of proper length a correlated frequency of functioning is established. For instance, in the case of the aforesaid embodiment in a car having a wheel base of 123 to 125 inches it has been found that a very effective and satisfactory control for the wheel mass and wheel size is provided when the parallelogram length in the embodiment described, may be from 14 to 16 inches depending upon wheel mass effect, and the length of the torque radius arm is approximately 44 to 45 inches between the axes of the trunnions and the center of the torque radius arm or rod rear pivot, measured along a perpendicular to transversely extending parallel perpendicular planes passing through said pivot center and containing said trunnion axes. Under these conditions the frequencies of operation are correlated so that under all normal operating speeds, (speeds in excess of 25 m. p. h.) no undamped forces of any magnitude are felt in the operation of the mechanism.

In résumé of the construction described it may be well to note that (1) the king pins or trunnions are substantially on the center lines of the wheels and are displaced laterally therefrom for stability and forwardly for an optimum caster effect, (2) longitudinal stability of wheel location is established by the torque or radius arms while transverse stability is obtained and maintained by the parallelograms, (3) the caster is at substantially an optimum at ⅛", (4) the wheel toe-in is normally zero, (5) the wheels are without camber which is zero, (6) the arrangement of the spindle arms, the tie rods, the swinging arm 24 and the several pivots and connections thereof give substantially correct, and, for practical purposes, correct steering geometry, and (8) there is what may be termed synchronous balance of operative reaction forces which is obtained by the frequency control established by the parallelogram length, the spring frequencies, the character, arrangement and location of the radius torque rods, the load point of application and an actual reaction frequency of unsprung weight. Of course the construction described gives many other advantages including low manufacturing and maintenance costs as will be obvious.

When a transverse elliptic spring is or semi-elliptic springs are used, cross stabilization is secured without the use of auxiliary devices, and the center of roll of the vehicle is changed so that centrifugal forces (as when rounding a curve) are minimized insofar as undesirable effects are concerned and the forces are resolved at a place more nearly approaching the center of gravity, thus making it possible to take a given curve faster than with a conventional design, with the same factor of safety. Another feature of the design lies in the fact that the rate of recovery from road shocks may be as great as approximately sixteen times that of the ordinary design, which increase in rate gives a much increased period of road contact for the tires. In this connection it may be noted that the shock absorbers or motion damping means on the inner ends of the lower parallelogram arms or links serve their primary purpose at low speeds and over minor variations of surface smoothness of the road and become decreasingly effective as the vehicle speed increases or as the magnitude of road surface irregularities increases. At higher speeds and with road irregularities of substantial size the inertia of the sprung mass of the vehicle and the relatively synchronous balance of the mechanisms described, make shock absorbers and shock absorber action wholly unnecessary.

A preferred form of the invention has been shown and described for the purpose of illustra-

UNITED STATES PATENT OFFICE

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MOTOR VEHICLE CONSTRUCTION

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This invention relates primarily to the construction of the steering or dirigible end of automotive and other vehicles and, more particularly, to the wheel mounting and securing arrangements, to the spring mounting and suspension, and to the steering mechanism and the connections thereof between the fixed portions of such mechanism, such as the steering column and pitman, and the dirigible wheels and related parts. In certain aspects the invention is related to and includes features of improvement upon and certain features generic to the invention or inventions disclosed in my copending application Serial Number 140,463, filed May 3, 1937. Certain features of the invention are as applicable to non-dirigible wheels as to dirigible wheels, as will become apparent.

The ordinary design of automotive vehicle front ends, that is, the dirigible or steering parts, whether front or rear ends, is a complicated and tedious task owing to the multitude of variable factors which must be taken into account and most, if not all, of which are more or less mutually interdependent to the extent that variations in any one factor may affect all of the other factors. In the so-called Ackerman principle of steering or arrangement of front axle or end construction as improved and now commonly used, the front wheels are mounted on individual pivots called king pins but are connected by a tie rod and to the steering wheel through the steering column, in such manner as will permit the wheels to be moved or steered together in order to turn the vehicle. In order to attempt to keep the wheels running true with respect to the center of the turning circle, the Ackerman principle requires that the spindle arms, which connect the tie rods and wheels, be set obliquely inward from the wheels, and the angles and distances must be fixed with a precision not always observed. Each wheel is also given caster, camber and toe-in.

Caster, of course, is used to throw the center of road contact of the wheel behind the effective center of pivoting or swinging of the wheel in turning the vehicle, while the wheel is given camber to bring the center of road contact of the wheel as nearly directly under the point of wheel pivot (king pin) loading as is reasonably possible, and toe-in is used cooperatively to correct for camber and caster effects, for control over road conditions and to produce stability of direction and control under normal operation. Each of these factors may exert a definite influence upon each of the others and all play an important part in the steering of the ordinary vehicle.

The complications attendant upon the introduction of the factors of caster, camber and toe-in have been appreciated for a long time but efforts to avoid them have been more or less unsuccessful. When there is too much caster the wheels are difficult to turn from a straight path and when there is too little caster there may be weaving and wandering or shimmy. If the camber is too much, too little or unequal as between the wheels the tires are worn unevenly and undesirably, and steering difficulties are encountered, and, if the toe-in is not correct similar troubles ensue. The problems have not been simplified but rather have been rendered more and more complex with the introduction of larger tires with less air pressures, the advent of independently sprung wheels, both of which look primarily to the comfort rather than the safety of the vehicle occupants, and the use of higher and higher vehicular speeds. Safety factors, particularly those dependent upon the human equation, the vehicle driver, have not kept pace with those problems.

Among the steering problems is that of turning radius, fundamentally that angle in the steering geometry which holds each front wheel tangent to the circle on which it should travel in making a turn. Since the front axle is not mounted on a center pivot and the front wheels do not turn with the axle, as in a wagon, but are independently pivoted on king pins or the like, in order to maintain the wheel axle axes coincident with radii of the turning circle, the wheels must be turned at differential rates so that the inside wheel, on the turn, will swing through a greater angle for each given increment of angular movement of the outside wheel, thereby to maintain the proper turning radius. This problem is affected by each of the factors of camber, caster, and toe-in and, in turn affects those factors, so that each factor may be said to be more or less inextricably dependent upon each of the other factors in the ordinary design.

The complexity of front end design is further complicated by the spring design and suspension, by tire construction and inflation and by other factors and conditions as will be appreciated. The character of the spring, its location and points of connection may vitally affect the steering particularly under operating conditions. When one of the wheels strikes an obstruction or a depression in the road, the deflection of the spring may permit a considerable momentary

change in the camber and toe-in or may even (temporarily at least) create an unsafe condition including undue driver fatigue. Weakened or weakening springs as well as shifting springs, wear in king pins and shackles and other parts, bent or displaced axles, and various other troublesome conditions, a large part of which may be attributed to the complexity of present designs of dirigible front ends, also play their part in affecting the steering through changes in camber, caster, and toe-in and other factors.

Among the numerous factors to be considered in designing the dirigible parts such as the front end of an automobile are a number heretofore disregarded or neglected. When, for instance, a member and its point of reception of forces are so designed and located that stressing forces encountered may operate with an effective leverage or leverages, the loading or stresses on the member and other members associated with it are multiplied, and, perhaps, differ directionally from the direction of the initial forces. There must be compensation for these leverage effects otherwise they would be transmitted to various parts of the front end including the steering mechanism and would seriously affect the steering and general roadability of the car. And in ordinary designs compensation is provided to a small extent initially by tight bearings and other connections, by high steering ratios and by the provision of the usual shock absorbers, etc., which decrease the roadability of the car, but when wear occurs, even this small compensation is lost. The correct solution to the problem, however, lies largely in the elimination of the effective leverages or in the reduction of those leverages to as near zero values as possible.

Other forces commonly overlooked are those forces which arise through unbalanced rotating parts or through the application of unbalanced forces to rotating parts. For example, when a tire or a wheel is out of balance (dynamic or static) or when the brake drum is so located that its reaction effects work at a leverage angle, the forces resulting therefrom create a condition where the wheel alignment and roadability may be considerably affected. In the case of a brake drum location of such character, an application of the brakes may cause the vehicle to 'duck' to one side or the other, and may cause or tend to cause wheel 'tramp' or 'shimmy' as well as produce other undesirable results. These various force-leverage effects are quite unsatisfactory from the standpoint of driver comfort as well as from the aspect of safety.

Consequently, one of the primary objects of this invention is to minimize the problem of design of a vehicle front end construction in such ways and to such extent as will eliminate elaborate and expensive engineering calculations and construction, as will effect substantial economies in labor and material in manufacture and maintenance, as will provide increased strength or safety factors regardless of decrease in materials, parts, weight and labor, as will reduce road hazards, as will reduce or eliminate tire scuffing, cupping and other forms of wear, as will give easier steering with the elimination of practically all road shock, road tramp, shimmy, weaving or wandering, and, in short, as will improve and simplify the design, construction, operation and maintenance of a vehicle to a substantial degree.

Another important object is to provide a construction for the mounting, suspension and steering of the dirigible wheels of a vehicle wherein the moments of forces reacting against the wheel and through its mounting and suspension against and through the steering mechanism to the steering column and steering wheel, are resolved in such a manner as to bring them substantially to zero, with the result that such effects as wheel shimmy, tramp, pull, weaving and so forth are inhibited or cannot develop and with the further result that steering may be made easier as by reduction of the steering ratio to a lower ratio than with ordinary designs.

Another object is to provide a design wherein the ratio, proportions and arrangements of the parts is such that the reactive effects of weight mass, inertia force and the forces of resilient supporting means are self absorbing in the system to the end that no shock absorber action is necessary except when the velocity of the inertia forces in a vertical direction is relatively different from the velocity of the forces of the resilient supporting means.

Another object is to arrange, construct and mount the radius torque rods so that each may function at relatively low frequency and substantially as a mass, and so that in combination with the parallelogram linkage of the wheel mounting which has a relatively higher frequency and with the wheels themselves, a relationship is established which tends toward minimum displacement of the vehicle mass under rough or uneven road conditions. In this connection it may be noted that the invention contemplates the provision of radius torque rods of great length and located in a novel manner.

Another object is to provide a construction for the dirigible wheels of a vehicle wherein the wheels have an optimum amount of caster but wherein camber is rendered wholy unnecessary and toe-in is reduced substantially to zero.

Still another object is to provide a construction whereby the mean plane of rotation of each wheel is at all times perpendicular to the normal or mean horizontal plane of, say, the frame of the vehicle, even as the wheels rise and fall under varying loading or under varying road surface conditions, thereby to eliminate undesirable gyroscopic effects commonly encountered in most of the present designs.

A further object is to provide a steering mechanism whereby the wheel at the inside of any given turn will swing about its vertical pivot axis through arcs increasingly greater than the arcs through which the wheel at the outside of the turn swings so that the plane of rotation of each wheel will constantly lie tangent to the circle on which such wheel should run in making the turn and so that projections of the axes of rotation of the front wheels will at all times intersect one another substantially on a projection of the common axis of the rear wheels or, will intersect a line perpendicular to and intersecting a projection of the common axis of the rear wheels and perpendicular to a generally horizontal plane such as the mean plane of the vehicle frame.

Further objects are to provide simple and economical constructions by and through which the foregoing and other objects may be attained, the constructions including a special form and arrangement of floating wheel and wheel mounting, a special wheel spindle and turning pivot arrangement, a special spring suspension and mounting, special shock absorbing or damping devices, special steering mechanism, a special torque or radius arm, and various other important

features mutually contributing to the desired results and ends to be reached.

Many other objects as well as the advantages and uses of the invention will become apparent and will be understood by those skilled in the art after reading the following description and claims and after viewing the drawings in which:

Fig. 1 is a top plan view, somewhat schematic in character, of the front or dirigible end of the chassis of an automobile, showing a preferred form of the invention applied thereto; the engine and other mechanism being omitted for the sake of simplification.

Fig. 2 is a top plan view on a larger scale than the scale of Fig. 1, of the upper left hand corner portion of the mechanism illustrated in Fig. 1.

Fig. 3 is a rear elevation of the mechanism shown in Fig. 2 and to the scale of the latter.

Fig. 4 is a view with some parts in vertical section taken along the section line IV—IV of Fig. 2 looking forward, and on the same scale as Figs. 2 and 3.

Fig. 5 is a section taken substantially along the line V—V of Fig. 2 and on the scale thereof.

Fig. 6 is a vertical section of details of connection between a tie-rod and a spindle arm, taken substantially along section line VI—VI of Fig. 2 but on a larger scale.

Fig. 7 is a horizontal section looking upward, taken substantially along the line VII—VII of Fig. 4, showing the details of construction of a damping mechanism or shock absorber, the scale being greater than that of Fig. 4.

Fig. 8 is a perspective view of one of the parallel arms of a wheel carrier structure showing part of one of the shock absorbing or motion damping mechanisms, and

Figs. 9 and 10 are diagrammatic illustrations of the manner in which an automobile equipped with the invention may be steered.

The portion of the chassis and running and steering gear shown in Fig. 1 includes longitudinally extending channel frame members 11 and 12 joined at their front end portions by a transverse member 13, a semi-elliptical spring 14 carried by a saddle member (not shown) attached to frame member 13 by U-bolts 15, wheel carrier means generally designated 16 and 17, wheels 18 and 19, radius rods 21 and 22, a rearwardly extending bracket 23, forming part of the spring saddle and carrying a swinging arm 24 pivoted thereto at 24a, tie rods 25 connected between the wheels 18 and 19 and arm 24, a pitman 26, and a drag link 27 connecting the pitman and arm 24. The construction and arrangement of the steering mechanism, insofar as the spindle arms, tie rods, pivot arm 24, bracket 23, drag link and locations of pivot connections between them are concerned, are so similar to the steering mechanism disclosed in said copending application that they may be considered identical. In the construction of the embodiment of the invention illustrated no axle as such is utilized, the parts referred to as the wheel carrier means 16 and 17 together with other mechanism and members serving the purposes of an axle as well as performing other functions. Each wheel carrier means is similar to the other, for which reason a description of either will suffice for both although there are certain relationships between them as will appear. The left front wheel carrier and its associated mechanisms have been illustrated and will be described, in detail.

Referring for the moment to Figs. 2, 3, 4 and 7, it will be noted that a generally U shaped bracket 28, the arms of which are formed as relatively deep vertically extending flanges 29, with relatively narrow horizontal flanges 31, has the ends of its arms formed or bent at right angles to the flanges 31 to provide portions 32 which lie against the outer face of the bottom of channel frame member 11. A sheet of rubber or other insulating material 33, may be disposed between the flanges 31 and 32 of the bracket, while bolts 34 secure the bracket 28 to the channel member. A steel filler sheet 30 is disposed between the flanges 31 and a rearwardly extending flange 13' on the transverse member 13, a sheet of rubber or other resilient material 33' overlies the flange 13', and a steel cap plate 33'' is superposed on the rubber and all are held together by the bolts 34 and 34'.

Pivotally supported by the bracket 28 and between the vertically depending flanges 29 thereof are a pair of arms 35 and 36, the upper of which is bent slightly at 37, for the purpose of permitting the same to swing upwardly through its maximum required distance without interference with the channel frame member. The arms 35 and 36 are substantially parallel and are pivoted on pivots, the axes 38 and 39 of which are perpendicular to a vertical plane, extending transversely of the vehicle. At their opposite ends the arms are pivotally connected by pivots, the axes 41 and 42 of which are parallel to one another and to the axes 38 and 39, to a yoke member 43. The pivot axes 41 and 42 are spaced apart substantially the same distance that the axes 38 and 39 are spaced apart, and extend parallel therewith, so that a plane containing the axes 41 and 42, when the arms are in any selected position, will lie parallel to all other planes containing the axes 41 and 42 as the arms 35, 36, swing up and down in a vertical plane to different positions.

The yoke member 43 has forked arms 44, each of which carries a fixed bushing 45, within which a king or trunnion pin is disposed and fixed and held against displacement by a snap ring 47 engaged in an undercut slot 48 in the bushing, while a welch plug 49, may be used to close the outer end of the bushing. Each king or trunnion pin 46 has a reduced inner end portion 51, on which one race member 52 of a bearing is mounted, the other race member 53 being carried by a part of the wheel hub structure. Balls 54 roll in the races and the bearings are of the sealed-lubricant type closed by sheet metal rings 55 and 56. A wheel hub member of cast steel 57, the formation of which is best illustrated in Fig. 5, is provided with vertically spaced wells or recesses, the walls of which are designated 58, within which the bearing members 53 are disposed, and it has a transversely extending central cylindrical portion 59, within which the wheel spindle 61, and the wheel spindle bearings, including outer race 62, inner race 63, and balls 64, are carried. The wheel spindle has a shouldered flange 65, which is drilled and tapped at suitable places for the reception of stud bolts 66, with which the brake drum member 67 is attached to the spindle. The hub member 57 also carries forwardly and rearwardly extending flanges 68, which are suitably drilled and tapped for the reception of bolts 69, by which a drum backing plate 71 is secured thereto. A spindle arm 72 is also secured to the casting 57 by the rearwardly extending flange 68 thereof and by means of one pair of the bolts 69.

The spindle bearing race member 62 is held in place in the hub member 57 by wedging snap rings 73 and 74, which engage in circumferential

recesses or grooves provided in the casting 57 and press against the ends of the race member. The wheel spindle 61 has a circumferential shoulder 75, against which one end of race member 63 abuts and which positions the spindle with respect to the spindle bearing, while a wedging snap ring 76, engaged in a circumferential recess or groove formed in the inner end of the spindle and pressing against race member 62, serves to secure the spindle within the bearing with the bearing race member 63, abutted against the shoulder 75. Dust caps 77 of sheet metal and having a friction fit with the respective parts with which they are shown to be engaged, may be utilized to protect the spindle bearing.

While the wheel has a certain amount of caster, as will be described, it has no initial camber or toe-in. The king or trunnion pins 46 have a common axis which lies in a vertical plane which may be parallel to the planes containing the pivot axes 38, 39, and 41, 42, and this common axis is also perpendicular to the normal horizontal plane of the vehicle chassis. The axis of the spindle 61 and spindle bearings is perpendicular to the vertical planes containing the pivot axes 38, 39 and 41, 42, but lies slightly rearward (about ⅛'' in a full size construction) of the common axis of the king or trunnion pins, as indicated by the legends designating the center line of the spindle and center line of the trunnions on Figs. 2 and 5 of the drawings. The mean plane of rotation of the wheel, as indicated by the legend "C wheel" in Fig. 2 is disposed slightly outward of (about ¼'' in the full size construction mentioned, supra) and parallel to a longitudinally extending plane containing the common axis of the king pins or trunnions when the wheel is running straight ahead, while the flange 78 of the brake drum extends substantially equal distances to each side of the said plane containing the common axis of the king pins thereby balancing the braking efforts and preventing the wheel from 'ducking' to one side or the other. The wheel proper, of course, may be attached to the brake drum member 67 by means of bolts which pass through the wheel spoke or disc structure into suitably disposed and tapped openings 79 formed in the drum member 67. The disposition of the axis of the wheel spindle rearwardly of the common axis of the king or trunnion pins is sufficient to provide the necessary caster, and the disposition of the center of tread or central plane of rotation of the wheel slightly outward of a parallel longitudinal plane containing the common axis of the king or trunnion pins produces or tends to produce a certain stability, as will be understood by those skilled in the art. While a brake shoe 80 with its attached lining are shown in Figs. 4 and 5, no attempt has been made to illustrate any other parts of the wheel brake mechanism which form no part of the present invention.

The yoke member 43 is rigidly and more or less integrally connected, as by welding, with a box skirt or housing member 81 the walls of which are spaced sufficiently far from the parallel link arms 35 and 36 as to avoid them during maximum relative vertical movements, but close enough to afford a certain amount of protection to the parts surrounded. However member 81 serves other functions, for, among other things, it supports a forwardly extending bracket 82 upon and to which one end of spring 14 is seated and secured, and it serves as an anchorage or abutment for the forward end of the torque, thrust or radius rod 21, the member 81 and rod 21 being welded or otherwise rigidly and, in effect, integrally secured together.

The bracket 82 which may also be welded to member 81, has a bottom wall 83 which is apertured as at 84 for passage of an anchor bolt 85. Portions of the wall 83 are depressed as at 86 around the aperture or slot 84 to provide a spherical seat for a resilient (rubber or composition) ball 87 which surrounds the upper portion of the stem of bolt 85 and is capped by a metal cap 88. The lower end of the bolt 85 passes through an aperture in the end of the spring 14 and like the upper end is equipped with a resilient ball 87' held between a metal cap 88' and a spherical socket 89 seated against the spring leaf at the bolt aperture or within the aperture. A spacer bushing 91 serves to hold the spring and bracket wall 83 in proper relationship. As will be appreciated, the spring may be secured to member 81 in other ways although the arrangement shown and described has been found to be desirable in actual constructions.

The radius or torque rod or arm 21 is of box section and may be formed of relatively heavy gauge sheet steel bent to box section and welded. It may be formed integral with the skirt or housing member 81, rather than separately therefrom and welded thereto. In longitudinal side elevation it may be straight dipping slightly to clear the adjacent tie-rod although the section decreases in all overall dimensions to its rear end at which place it may be equipped with a ball (not shown) to make, substantially, a universal joint with a socket formed in a bracket 92 and a cap 93. The bracket 92 may be secured to one of the longitudinal frame members 11 and 12 as indicated in Fig. 1. It will be noted that each of the radius rods at its front end extends over a substantial transverse area which includes areas closely adjacent to the pivots 41 and 42, to the common axes of the trunnions and to the center of the wheel spindle bearing, and that it is disposed almost directly rearward of the spring connection with the brackets 82. In longitudinal plan each radius rod is curved inwardly of the chassis for a short distance at its front end to provide clearance for the front wheels as they are turned in steering, but returns outward and rearward to the ball and socket joint with the brackets 92 on frame member 11 or 12. Preferably the center of the ball and socket joint between a radius rod and a bracket 92 lies substantially in longitudinal alignment in plan with the center line or axis of the trunnions and substantially in longitudinal alignment in elevation with the center of the wheel spindle and bearing under normal conditions. The radius rods should be of substantial length as indicated in the drawings and in no event should be less than twice and, preferably, thrice the mean length of the parallel arms or links 35, 36 between the pivot centers thereof. In practice the radius rods should be just as long as is commercially expedient.

Each of the parallel arm pivots of which the axes are numbered 38, 39, 41, and 42, is preferably constructed with needle bearings as represented in the lower right hand portion of Fig. 4, wherein needles 94 are disposed between hardened spaced bearing sleeves or bushings 95 and 96. The sleeves 95 surround pivot bolts 97 and 98 and serve as spacers as will be understood; however the bolts 97 pass through the arms of a yoke member 99 and through enlarged apertures or

recesses or grooves provided in the casting 57 and press against the ends of the race member. The wheel spindle 61 has a circumferential shoulder 75, against which one end of race member 63 abuts and which positions the spindle with respect to the spindle bearing, while a wedging snap ring 76, engaged in a circumferential recess or groove formed in the inner end of the spindle and pressing against race member 63, serves to secure the spindle within the bearing with the bearing race member 63, abutted against the shoulder 75. Dust caps 77 of sheet metal and having a friction fit with the respective parts with which they are shown to be engaged, may be utilized to protect the spindle bearing.

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Each of the parallel arm pivots of which the axes are numbered 38, 39, 41, and 42, is preferably constructed with needle bearings as represented in the lower right hand portion of Fig. 4, wherein needles 94 are disposed between hardened spaced bearing sleeves or bushings 95 and 96. The sleeves 95 surround pivot bolts 97 and 98 and serve as spacers as will be understood; however the bolts 97 pass through the arms of a yoke member 99 and through enlarged apertures or

slots 101 in flanges 29. Within the yoke member 99 is a steel (tempered) spring 102 of yoke shape to the arms of which resistance or friction plates 103 composed of brake lining fabric or the like are secured as by rivets 104. The arms of spring 102 are given an initial set toward one another thereby to bring the plates 103 into tight frictional engagement with hard flat steel wear plates 105 which are welded or otherwise rigidly secured to opposite sides of the arms or links 36. One or more bolts or screws 106 pass through the back of yoke bracket 28, one or more rubber, fiber or other resilient pads 100, serving as spacing and as shock and sound absorbent means, the yoke member 99, and the spring 102 and being suitably attached to or associated with either the spring and member 99 and bracket 28, may be rotated to adjust the member 99, the spring 102 and the link 36 toward or from the back of yoke bracket 28, thereby to vary the wheel position. By varying the number and thickness of pads 100, various adjustments may be obtained. The wheels and their associated mechanisms are illustrated in positions of normal vehicle loading and adjustment but due to wear and practical construction difficulties, the adjustment provided by the screws 106 may be needed to set the wheels in such positions that their planes of rotation are vertical. Since the arms 36 are of tubular construction the ends are provided with pivot eye members 107 secured by rivets 108.

The tie rods 25 are of tubular construction as shown in Fig. 6 and are adjustably secured to universal joint socket members 109, split ends 111 having internal threads for engagement with similar threads on the stem 110 of socket member 109 and being clamped thereto by clamp screws 112. Each socket is adapted to receive a ball 113 carrying a stem 114 which passes through the spindle arm 72 and is held thereto by a nut 115 between a conical washer 116 and a flat washer 117. A spherical bearing cap or washer 118 backed by a spring 119 which is compressed between a plug 121 and cap 118, serves to hold the ball 103 in relatively tight frictional engagement with the socket bearing surfaces. The joints or connections between the tie rods 25 and the swinging arm 24, the joint between the arm 24 and drag link 27 and the joint between the drag link 27 and pitman or steering arm 26 may all be constructed after the manner of the joints between the spindle arms and the tie rods, as just described.

The arrangement and operation of the steering mechanism are similar to the arrangement and operation of the steering mechanism of the aforesaid copending application Serial No. 140,463 as above noted, except that the tie-rods are independently connected with the arm 24 instead of being jointly connected by a single pivot connection. The relative positions or locations of connections may be considered to be the same. The steering arrangements and operation will be explained herein by reference to Figs. 9 and 10 which diagrammatically illustrate the angles through which the inside wheel will turn for given increments of angular change in the outside wheel in making a turn with a vehicle having a certain wheel base and a certain transverse wheel span, using the mechanism illustrated, thereby to maintain intersection of the dirigible wheel axes substantially on the common axis of the rear or fixed wheels or intersection of the dirigible wheel axes with a perpendicular line in a perpendicular or vertical plane containing the common axis of the rear or fixed wheels. To this end Fig. 9 diagrams a vehicle having a wheel base of 125 inches and a wheel span (tire tread center to tire tread center with the wheels parallel for straight ahead running) of 57 inches. In such case with the angle A known (assumed) the angles B, C, D, E, and F and the distances a and b, may be figured trigonometrically, as will be apparent, so that by assuming or assigning different values to the angle A, the exact corresponding angles F may be computed, thus determining the exact differential turning movements of the inside wheel to maintain the intersection of projections of the axes of the dirigible wheels on the projection of the common axis of the fixed or non-dirigible wheels.

Applying the required formulae to the instant construction and utilizing a length of 5¾ inches for the bracket 23 between the line of axes of the wheel spindles 61 and the center or axis of pivot 24a and a radius length of 4⅞ inches for the swinging arm 24 between pivot center 24a and the centers of pivotal connections of tie rods 25 to arm 24, the angles A to F' inclusive and the distances a and b will be as given in the chart immediately following this paragraph. It is to be understood that the angles are given in degrees and minutes while the distances are given in inches. In order to show how closely the illustrated embodiment, with the dimensions given, will cause the inside wheel to move through the correct angle for each increment of angular movement A of the outside wheel, the extreme right hand column of the chart gives the theoretically or ideally correct angle F for corresponding angles A.

A	B	a	C	b	D	E	F' on layout	F
5°	85°	1,430	5°	1,373	84° 48'	12'	4° 54'	5° 12'
10°	80°	710	10°	653	79° 10'	50'	10° 6'	10° 50'
15°	75°	467	15°	410	73° 1'	1° 59'	15° 18'	16° 59'
20°	70°	343.5	20°	286.5	66° 25'	3° 35'	21° 11'	23° 35'
25°	65°	268.2	25°	211.2	59° 24'	5° 36'	29° 23'	30° 36'
30°	60°	216.5	30°	159.5	51° 54'	8° 6'	36° 42'	38° 6'
31° 14'	58° 46'	206	31° 14'	149	50°	8° 46'	39° 16'	40°

The distance between the centers of pivotal connection 20, 20 (see Figs. 1 and 10) of the tie rods with the swinging arm 24 plays some part in the steering geometry but for the purposes of this application disclosure is relatively unimportant and has been neglected in the computations of the figures of columns F and F' of the above chart. In an actual embodiment of the invention utilizing the dimensions given, this distance is 1¾ inches while each tie rod length between pivot centers is approximately 25$\frac{1}{16}$ inches and each spindle arm length measured as the shortest distance from the center of its pivotal connection with the tie rod to the trunnion axes is 6½ inches.

The operation of the described mechanisms is relatively simple. With the vehicle running straight ahead, should either wheel or both wheels strike a depression the wheel or wheels will

drop while the vehicle body and other parts because of inertia and other effects tend to continue at the same level but each wheel, in dropping, will continue in planes of rotation which are parallel to its previous plane of rotation and parallel to one another. This action of course follows from the action of the parallel arms or links 35 and 36. Similarly the wheels rise on striking an abrupt rise in a road surface, maintaining parallel planes of rotation.

Owing to the fact that the common axis of the trunnions or king pins is practically centered with respect to the central or mean plane of rotation of the wheel, being offset inwardly by about ¼ of an inch in the embodiment mentioned, and to the fact that the trunnion axes are substantially perpendicular at all times to a normal or mean horizontal plane of the vehicle, braking forces and forces against the wheel in its course of travel are carried directly rearward and absorbed or dissipated with little transmission to the steering wheel, and the gyroscopic forces of the rotating parts do not fight against the steering mechanism. Not only are such forces received at zero or substantially zero leverages but the elimination of stub axles and connections between the links 35 and 36 with the trunnion carrying member and between the spring end and the pivot axes 41 and 42, and the location and arrangement of the radius rod, on each side of the vehicle, reduce the ordinary bearing loadings to a point where the steering ratios may be cut substantially in half for the same control effort. Furthermore the composite construction gives a relatively high control safety factor since most of the forces produced are absorbed without entering the steering linkage so that, as in actual tests, a tire may be driven on while flat or may blow or the car may be driven over a high curb or the like, at high speed without relative danger.

In the design of a construction for independently mounting vehicle wheels, if the component parts are such as to establish frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no exterior means, such as a shock absorber, is necessary as a component part of the mechanism because the function of the shock absorber is to bring to rest unbalanced or undamped forces which are incident to the operation of an unbalanced mechanism. This relation of parts in the present embodiment of the invention is established by making the torque radius rods or longitudinal control members as long as possible so that the frequency of functioning of such members will be as low as possible, and so that each will function as an entirety and with its adjacent wheel, more as a weight effect rather than as controlling the periodicity of functioning as does a pendulum in a clock mechanism.

This wheel mass and that portion of the weight of the torque radius rod which may be considered a part of the wheel mass has a definite frequency which is a matter related to mass, tire size and amount of air pressure of the tire, and the car spring also, by design, has an established frequency of functioning similar to a tuning fork. By making the length of the parallelogram linkage (35 and 36) of proper length a correlated frequency of functioning is established. For instance, in the case of the aforesaid embodiment in a car having a wheel base of 123 to 125 inches it has been found that a very effective and satisfactory control for the wheel mass and wheel size is provided when the parallelogram length in the embodiment described, may be from 14 to 16 inches depending upon wheel mass effect, and the length of the torque radius arm is approximately 44 to 45 inches between the axes of the trunnions and the center of the torque radius arm or rod rear pivot, measured along a perpendicular to transversely extending parallel perpendicular planes passing through said pivot center and containing said trunnion axes. Under these conditions the frequencies of operation are correlated so that under all normal operating speeds, (speeds in excess of 25 m. p. h.) no undamped forces of any magnitude are felt in the operation of the mechanism.

In résumé of the construction described it may be well to note that (1) the king pins or trunnions are substantially on the center lines of the wheels and are displaced laterally therefrom for stability and forwardly for an optimum caster effect, (2) longitudinal stability of wheel location is established by the torque or radius arms while transverse stability is obtained and maintained by the parallelograms, (3) the caster is at substantially an optimum at ⅛", (4) the wheel toe-in is normally zero, (5) the wheels are without camber which is zero, (6) the arrangement of the spindle arms, the tie rods, the swinging arm 24 and the several pivots and connections thereof give substantially correct, and, for practical purposes, correct steering geometry, and (8) there is what may be termed synchronous balance of operative reaction forces which is obtained by the frequency control established by the parallelogram length, the spring frequencies, the character, arrangement and location of the radius torque rods, the load point of application and an actual reaction frequency of unsprung weight. Of course the construction described gives many other advantages including low manufacturing and maintenance costs as will be obvious.

When a transverse elliptic spring is or semi-elliptic springs are used, cross stabilization is secured without the use of auxiliary devices, and the center of roll of the vehicle is changed so that centrifugal forces (as when rounding a curve) are minimized insofar as undesirable effects are concerned and the forces are resolved at a place more nearly approaching the center of gravity, thus making it possible to take a given curve faster than with a conventional design, with the same factor of safety. Another feature of the design lies in the fact that the rate of recovery from road shocks may be as great as approximately sixteen times that of the ordinary design, which increase in rate gives a much increased period of road contact for the tires. In this connection it may be noted that the shock absorbers or motion damping means on the inner ends of the lower parallelogram arms or links serve their primary purpose at low speeds and over minor variations of surface smoothness of the road and become decreasingly effective as the vehicle speed increases or as the magnitude of road surface irregularities increases. At higher speeds and with road irregularities of substantial size the inertia of the sprung mass of the vehicle and the relatively synchronous balance of the mechanisms described, make shock absorbers and shock absorber action wholly unnecessary.

A preferred form of the invention has been shown and described for the purpose of illustra-

having spaced arms straddling one end of said hub member and secured to said trunnion members, a pair of links spaced apart and extending parallel to one another in a substantially vertical plane extending generally transverse of the vehicle, one end of each link being pivotally connected with said yoke member adjacent to said spindle end, a brake drum carried by the other end of said spindle and overhanging said trunnions a substantially equal amount on each side thereof, a drum backing plate carried by said hub member, a housing member carried by said yoke member and surrounding a portion of the said pivoted ends of said links and in spaced relation thereto, and a spring seat carried by said housing portion forwardly of said links.

13. In the construction of the dirigible portion of a vehicle, a pair of wheels mounted for movements relative to one another in substantially parallel planes of rotation when running straight ahead, a frame structure, means mounting each of said wheels for turning about a substantially vertical axis, means providing a transverse connection between each wheel and said frame structure, and a radius rod associated with each of said transverse connecting means adjacent to the axis of turning of its related wheel and pivotally associated with said frame structure at a place rearward of and substantially in longitudinal alignment with the axis of turning of its related wheel.

14. In the construction of the dirigible portion of a vehicle, a pair of wheels, a frame structure, means including a pair of parallelogram mechanisms, one mechanism pivotally connecting one wheel with said frame structure at one side and the other connecting the other wheel at the other side of said frame structure for maintaining said wheels in substantially parallel planes of rotation when running straight ahead, means pivoting each wheel for lateral turning movements, and a longitudinally directed radius rod connected at its forward end with a portion of each of the first said means and extending rearwardly and secured to said frame structure at a place substantially in longitudinal alignment with said pivoting means of its related wheel.

15. In the construction of the dirigible portion of a vehicle, a pair of wheels, a non-rotating hub connecting part for each wheel, a frame structure between said wheels, a pair of parallelogram mechanisms, one mechanism pivotally connecting one wheel by a hub connecting part with said frame structure at one side and the other connecting the other wheel at the other side of said frame structure for maintaining said wheels in substantially parallel planes of rotation during vertical movements when the wheels are running straight ahead, means pivoting each wheel on a substantially vertical axis for lateral turning movements, a pair of rearwardly extending radius rod members, each of said members being substantially rigidly secured to one of said hub connecting parts at its forward end and pivotally secured at its rearward end to said frame structure at a place substantially in longitudinal alignment with the said vertical pivot axis of the corresponding wheel, and a semi-elliptical spring carried intermediate its ends by said frame structure and secured at its ends to said hub connecting parts at places adjacent to said wheels.

16. In a mounting for a wheel of a vehicle, a frame, a wheel member, a transverse stabilizing means for said wheel member including substantially parallel arms disposed one above the other transversely of the vehicle, said arms being pivotally connected at corresponding ends with said frame and with said stabilizing means, and a torque-radius control means operatively associated with said stabilizing means and wheel adjacent to said wheel member and extending toward the opposite end of the vehicle for longitudinal alignment of said wheel member, said torque-radius control means being of substantially greater length than said arms and having connection with said frame at a place substantially in line with the mean path of longitudinally directed forces applied against the wheel when running straight ahead.

17. In a vehicle dirigible wheel mounting, a frame structure, a wheel including a spindle and a substantially non-rotative hub member connected with said frame structure transversely of the vehicle, a wheel carrier including a substantially vertical pivot associated with said hub member about which said wheel may swing in steering movements, a brake drum associated with said spindle, said drum having a braking surface the center of the effective braking area of which is substantially in alignment with the axis of said pivot, and a longitudinally extending radius rod member substantially rigidly connected with said carrier means at its forward portion and flexibly secured to said frame structure at a rearward portion and at a place substantially in longitudinal alignment with said center of the effective braking area of the drum.

18. In a vehicle dirigible wheel mounting, a frame structure, a wheel including a spindle and a substantially non-rotative hub member connected with said frame structure transversely of the vehicle, a wheel carrier including a substantially vertical pivot associated with said hub member about which said wheel may swing in steering movements, a brake drum associated with said spindle, said drum having a braking surface the center of the effective braking area of which is substantially in alignment with the axis of said pivot, and a longitudinally extending radius rod member substantially rigidly connected with said carrier means at its forward portion and flexibly secured to said frame structure at a rearward portion and at a place substantially in longitudinal alignment with said center of the effective braking area of the drum, said transverse connection between said wheel and frame structure including substantially vertically spaced parallel arms pivotally connected at corresponding ends with said frame structure and with said wheel carrier closely adjacent to said vertical pivot.

19. In a vehicle wheel mounting arrangement, a frame structure, a wheel, means including parallel links of substantially equal span arranged in a substantially vertical plane and pivotally associated at one end of each with said frame structure and at the other end of each with said wheel whereby said wheel may move vertically relative to said frame structure, and a longitudinally extending member associated at one of its end portions with said means and at its opposite end portion with said frame structure at a place substantially remote from said wheel and substantially in alignment with the plane of rotation of said wheel, said longitudinally extending member being at least twice as long as the mean span of said links between the pivot centers of the ends thereof.

20. In a vehicle wheel mounting arrangement, a frame structure, a wheel, a wheel carrier member, a pair of parallel links connecting said frame structure and wheel carrier member, and a radius

said frame, each locating means comprising, a pair of substantially parallel arms of substantially equal length extending substantially transversely of the vehicle and pivotally connected at one end of each with said frame for swinging movements in a substantially vertical plane, a pair of vertically spaced trunnions, means pivotally connecting the other ends of said arms in spaced relation with said trunnions for relative movements therebetween in a substantially vertical plane, the axes of said trunnions being substantially coaxial with one another and being perpendicular to a horizontal plane, and a wheel member including a spindle rotatably disposed between said trunnions, said spindle having a horizontal axis located rearwardly of the line of axes of the trunnions, a bracket non-rotatably carried by each locating means adjacent to its wheel member, a spring secured at a center portion to said frame and at its ends to said brackets, and a radius rod connected at one end with each of the first said means at a place substantially directly rearward of the end of the spring thereat and at its opposite end to said frame at a place substantially directly rearward of the wheel member and substantially in line with the center of rearward thrust on the wheel member when the wheel member is running straight ahead.

8. In a dirigible wheel assembly for a vehicle, a frame, wheel locating means at each side of said frame, each locating means comprising, a pair of substantially parallel arms of substantially equal length extending substantially transversely of the vehicle and pivotally connected at one end of each with said frame for swinging movements in a substantially vertical plane, a pair of vertically spaced trunnions, means pivotally connecting the other ends of said arms in spaced relation with said trunnions for relative movements therebetween in a substantially vertical plane, the axes of said trunnions being substantially coaxial with one another and being perpendicular to a horizontal plane, and a wheel spindle rotatably disposed between said trunnions, said spindle having a horizontal axis located rearwardly of the line of axes of the trunnions, a leaf spring between each of the trunnion and arm connecting means and said frame, and a radius rod rigidly secured at one end to each of said connecting means and pivotally secured at its other end to said frame at a place rearward of the connecting means, the center of the rear end of each radius rod lying substantially in a perpendicular plane containing the center of turning of the wheel immediately forward thereof when such wheel is running straight ahead.

9. In a vehicle wheel mounting construction, a hub member, a wheel spindle having a horizontal axis disposed within said hub member, spindle bearings between said spindle and said hub member, said hub member having a recess in the radially outer portion thereof at each of substantially opposite sides of the spindle axis, trunnion bearings disposed in said recesses for rotation in parallel horizontal planes and about a common axis perpendicular to a horizontal plane containing the axis of said spindle, said common axis lying ahead of the spindle axis in the direction of vehicle forward motion whereby to provide wheel caster, trunnion pins mounted in said trunnion bearings for rotation relative thereto on said common axis, a radius rod carrying said trunnion pins, a vehicle frame member, and means including parallel arms arrayed one above the other in a substantially vertical plane, pivotally connected at one end of each to said frame member and pivotally connected at the other end of each to said radius rod.

10. In a vehicle wheel mounting construction, a hub member, a wheel spindle rotatably mounted on a horizontal axis within said hub member, said hub member having a pair of oppositely directed recesses formed therein, one of said recesses being directed generally vertically downward away from the spindle and the other being directed generally vertically upward away from the spindle, trunnion bearings disposed in said recesses with their axes of rotation aligned with one another and extending perpendicular to the horizontal plane containing the axis of the spindle, the axes of rotation of said bearings being disposed ahead of said spindle axis in the direction of forward vehicle motion, trunnion members carried by said bearings and having axes of relative rotation coincident with the axes of the bearings, a rearwardly extending radius rod thrust member having forked arms with the arms secured to said trunnion members, a vehicle frame member, means connecting said radius rod member with said frame member at a place substantially in a vertical plane containing the axes of said trunnion members and extending longitudinally of the vehicle, and means including vertically spaced and parallel arms extending transversely of the vehicle and connecting said frame member and forked arm member for relative vertical movements therebetween.

11. In a vehicle wheel mounting construction, a hub member, a wheel spindle rotatably mounted on a horizontal axis within said hub member, a bearing member carried by said hub member above and a similar bearing member carried by said hub member below said spindle and intermediate the ends of the spindle, a trunnion member carried by each of said bearing members for relative rotation on aligned axes of rotation, the aligned axes of rotation extending substantially perpendicular to the horizontal plane containing the spindle axis, a yoke member having spaced arms straddling one end of said hub member with said arms engaging said trunnion members, a pair of links spaced apart and extending parallel to one another in a vertical plane containing the axes of said trunnions and extending transversely of the vehicle, one end of each link being pivotally connected with said yoke member adjacent to said spindle end, a skirt secured to said yoke member and disposed about and in spaced relation to portions of said pivoted ends of said links, a spring seat carried by said skirt, a frame member pivotally connected with each of the other ends of said links, and a radius rod extending rearwardly from and substantially integrally connected at one end to said skirt, the rearward end of said radius rod being pivotally secured to said frame member at a place substantially in longitudinal alignment with the axes of said trunnion members.

12. In a vehicle wheel mounting construction, a hub member, a wheel spindle rotatably mounted on a horizontal axis within said hub member, a bearing member carried by said hub member above and a similar bearing member carried by said hub member below said spindle intermediate the ends of the spindle, a trunnion member rotatably carried by each of said bearing members on aligned axes, said aligned axes extending substantially perpendicular to the horizontal plane containing the spindle axis, a yoke member

having spaced arms straddling one end of said hub member and secured to said trunnion members, a pair of links spaced apart and extending parallel to one another in a substantially vertical plane extending generally transverse of the vehicle, one end of each link being pivotally connected with said yoke member adjacent to said spindle end, a brake drum carried by the other end of said spindle and overhanging said trunnions a substantially equal amount on each side thereof, a drum backing plate carried by said hub member, a housing member carried by said yoke member and surrounding a portion of the said pivoted ends of said links and in spaced relation thereto, and a spring seat carried by said housing portion forwardly of said links.

13. In the construction of the dirigible portion of a vehicle, a pair of wheels mounted for movements relative to one another in substantially parallel planes of rotation when running straight ahead, a frame structure, means mounting each of said wheels for turning about a substantially vertical axis, means providing a transverse connection between each wheel and said frame structure, and a radius rod associated with each of said transverse connecting means adjacent to the axis of turning of its related wheel and pivotally associated with said frame structure at a place rearward of and substantially in longitudinal alignment with the axis of turning of its related wheel.

14. In the construction of the dirigible portion of a vehicle, a pair of wheels, a frame structure, means including a pair of parallelogram mechanisms, one mechanism pivotally connecting one wheel with said frame structure at one side and the other connecting the other wheel at the other side of said frame structure for maintaining said wheels in substantially parallel planes of rotation when running straight ahead, means pivoting each wheel for lateral turning movements, and a longitudinally directed radius rod connected at its forward end with a portion of each of the first said means and extending rearwardly and secured to said frame structure at a place substantially in longitudinal alignment with said pivoting means of its related wheel.

15. In the construction of the dirigible portion of a vehicle, a pair of wheels, a non-rotating hub connecting part for each wheel, a frame structure between said wheels, a pair of parallelogram mechanisms, one mechanism pivotally connecting one wheel by a hub connecting part with said frame structure at one side and the other connecting the other wheel at the other side of said frame structure for maintaining said wheels in substantially parallel planes of rotation during vertical movements when the wheels are running straight ahead, means pivoting each wheel on a substantially vertical axis for lateral turning movements, a pair of rearwardly extending radius rod members, each of said members being substantially rigidly secured to one of said hub connecting parts at its forward end and pivotally secured at its rearward end to said frame structure at a place substantially in longitudinal alignment with the said vertical pivot axis of the corresponding wheel, and a semi-elliptical spring carried intermediate its ends by said frame structure and secured at its ends to said hub connecting parts at places adjacent to said wheels.

16. In a mounting for a wheel of a vehicle, a frame, a wheel member, a transverse stabilizing means for said wheel member including substantially parallel arms disposed one above the other transversely of the vehicle, said arms being pivotally connected at corresponding ends with said frame and with said stabilizing means, and a torque-radius control means operatively associated with said stabilizing means and wheel adjacent to said wheel member and extending toward the opposite end of the vehicle for longitudinal alignment of said wheel member, said torque-radius control means being of substantially greater length than said arms and having connection with said frame at a place substantially in line with the mean path of longitudinally directed forces applied against the wheel when running straight ahead.

17. In a vehicle dirigible wheel mounting, a frame structure, a wheel including a spindle and a substantially non-rotative hub member connected with said frame structure transversely of the vehicle, a wheel carrier including a substantially vertical pivot associated with said hub member about which said wheel may swing in steering movements, a brake drum associated with said spindle, said drum having a braking surface the center of the effective braking area of which is substantially in alignment with the axis of said pivot, and a longitudinally extending radius rod member substantially rigidly connected with said carrier means at its forward portion and flexibly secured to said frame structure at a rearward portion and at a place substantially in longitudinal alignment with said center of the effective braking area of the drum.

18. In a vehicle dirigible wheel mounting, a frame structure, a wheel including a spindle and a substantially non-rotative hub member connected with said frame structure transversely of the vehicle, a wheel carrier including a substantially vertical pivot associated with said hub member about which said wheel may swing in steering movements, a brake drum associated with said spindle, said drum having a braking surface the center of the effective braking area of which is substantially in alignment with the axis of said pivot, and a longitudinally extending radius rod member substantially rigidly connected with said carrier means at its forward portion and flexibly secured to said frame structure at a rearward portion and at a place substantially in longitudinal alignment with said center of the effective braking area of the drum, said transverse connection between said wheel and frame structure including substantially vertically spaced parallel arms pivotally connected at corresponding ends with said frame structure and with said wheel carrier closely adjacent to said vertical pivot.

19. In a vehicle wheel mounting arrangement, a frame structure, a wheel, means including parallel links of substantially equal span arranged in a substantially vertical plane and pivotally associated at one end of each with said frame structure and at the other end of each with said wheel whereby said wheel may move vertically relative to said frame structure, and a longitudinally extending member associated at one of its end portions with said means and at its opposite end portion with said frame structure at a place substantially remote from said wheel and substantially in alignment with the plane of rotation of said wheel, said longitudinally extending member being at least twice as long as the mean span of said links between the pivot centers of the ends thereof.

20. In a vehicle wheel mounting arrangement, a frame structure, a wheel, a wheel carrier member, a pair of parallel links connecting said frame structure and wheel carrier member, and a radius

rod of substantially greater length than the mean length of said links substantially rigidly secured by one end portion to and extending longitudinally in the direction of the vehicle length from said carrier member, said radius rod at its other end portion being pivotally associated with said frame structure substantially in longitudinal alignment with the mean plane of rotation of said wheel.

21. In a vehicle wheel mounting arrangement, a frame structure, a wheel including a spindle therefor, a wheel carrier including a substantially vertical pivot about which the wheel may swing in steering movements, and a longitudinally extending radius rod member of substantial length substantially rigidly associated with said carrier means at its forward portion and pivotally connected at its rearward portion to said frame structure at a place substantially in longitudinal alignment with said vertical pivot.

22. In a vehicle wheel mounting, a rotatable wheel member, a non-rotatable hub member for said wheel member, a spindle secured to said wheel member and disposed in said hub member, bearings between said hub member and spindle, a frame member, a pair of relatively inflexible arms of substantially equal length disposed in spaced parallel array with one above the other and extending transversely of the vehicle between said frame and hub members, said arms being pivotally connected with said frame member at one end of each and pivotally associated at the other end of each with said hub member for vertical movements of said hub member relative to said frame member, and longitudinal stabilizing means pivotally associated with said hub member for lateral turning movements of the hub member relative thereto, said longitudinal means extending between said other ends of said arms and said frame member at a place a substantial distance from said hub member and connected with said frame member at said place.

ANTHONY J. METZ, Sr.

JA 60

July 5, 1938. O. SIEBLER 2,122,961

WHEEL SUSPENSION FOR AUTOMOBILES

Filed May 4, 1937

Fig. 1

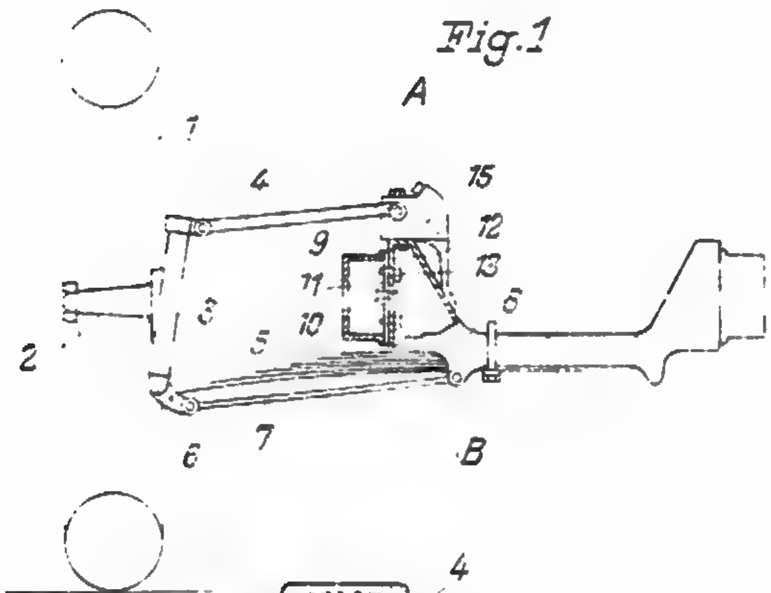


Fig. 2

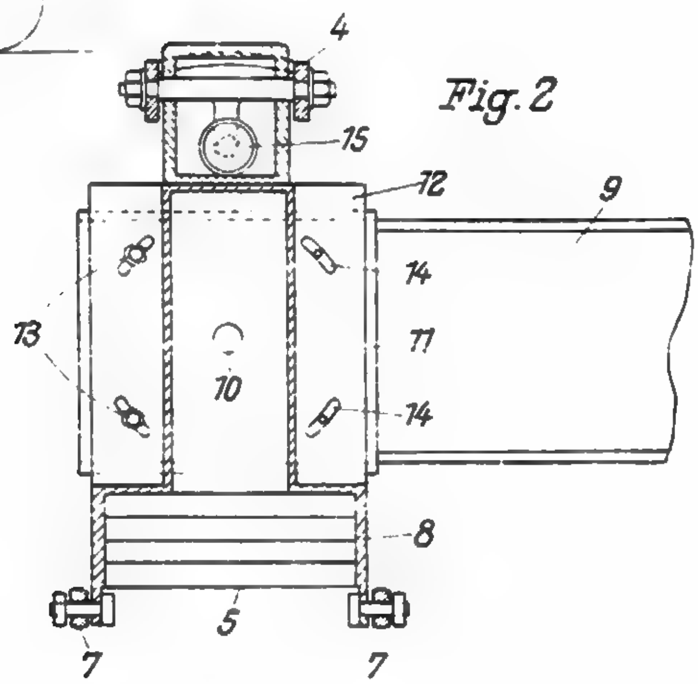
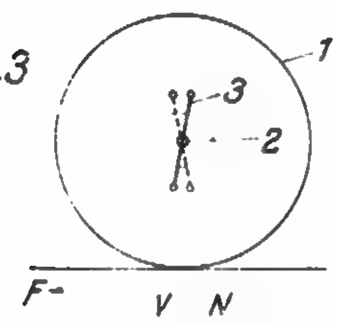


Fig. 3



Inventor:

Oscar Siebler

JA 61

Patented July 5, 1938 2,122,961

UNITED STATES PATENT OFFICE

2,122,961

WHEEL SUSPENSION FOR AUTOMOBILES

Oscar Siebler, Zwickau, Germany, assignor to Auto Union Aktiengesellschaft, Chemnitz, Germany

Application May 4, 1937, Serial No. 140,754
In Germany May 5, 1936

3 Claims. (Cl. 280—96.2)

The present invention relates to an automobile with independently suspended wheels. The independent suspension of the wheels is intended, amongst other things, to prevent the so-called shimmy, which is an undesirable occurrence with rigid axles. This is however, not entirely accomplished by the independent suspension but with certain conditions as to track and speed a slight shimmy of the wheels and swinging of the vehicle becomes noticeable, which has a detrimental influence on the running properties of the automobile.

In order to damp these shimmy movements, it has been proposed to make the swinging steering arms on the frame adjustable so that by displacing the engaging point of the upper link on the vehicle frame, the forward and rearward rake of the wheels individually is adjustable. In order to effect the adjustment of the forward and rearward rake of both wheels simultaneously, it has been proposed to swing the transverse spring, to the ends of which are connected the lower ends of the steering swivels, relatively to the frame whereby the forward or rearward rake of the wheels is varied. This structure however requires a spherical connection of the steering swivels to the links. This two-point connection of the steering swivels is improved according to the invention by a connection at several points, the links and transverse springs being connected to a common transverse member which is adjustable for the common adjustment of the forward or rearward rake of both wheels relatively to the frame and a transverse axis without affecting the suspension of the wheels. It may, therefore be made very stable as a suspension at several points independently of the adjustment of the forward and rearward rake. The transverse frame member is preferably provided with end flanges and is made rotatable and capable of being fixed on journals on the longitudinal frame member. The position of the transverse member is ensured by screws extending into elongated holes.

In the accompanying drawing the invention is illustrated diagrammatically with reference to a constructional example.

Fig. 1 shows the constructive arrangement in elevation and partly in section,

Fig. 2 is a section on the line A—B of Fig. 1,

Fig. 3 shows the possibility of adjustment of the forward and rearward rack.

1 is the wheel, which is secured in a known manner to the steering swivel 3 by means of its stub axle 2. The steering swivel 3 is connected with the frame at its upper end by means of the link 4 and at its lower end by the transverse spring 5. The link 4 is pivoted to the steering swivel as well as to the frame, so that in co-operation with the transverse spring 5, the steering swivel 3 is guided in the springing direction in the manner of a parallelogram. The spring plate 6 for the transverse spring 5 arranged at the lower end of the steering swivel 3 is prolongated, and its prolongation serves for pivotally attaching the auxiliary link 7 which at its other end is hinged to the frame. Accordingly the suspension of the spring 5 in the spring plate 6 must allow of a certain amount of play in the longitudinal direction. According to the invention the link 4, spring 5 and auxiliary link 7 are arranged on the frame on a separate transverse member 8. This transverse member 8 connects the two longitudinal members 9 together in such a manner that a frame is obtained which is highly resistant to twisting. The transverse member 8 is adjustable about a transverse axis and the adjustability is obtained by the longitudinal members 9 of U-shaped cross-section having journals 10 at their inner open sides, which, for example, are welded or affixed to a welded-on plate 11. The plate 11 serves as guiding surface for the transverse frame member 8 which is provided with flanges 12 and also contains the threaded holes for the securing screws 13. The end flanges of the transverse frame member 8 have holes lying in the swinging axis which serve for accommodating the journals 10 and also guiding slots 14 for the fixing screws 13. The transverse frame member 8 can thus be swung in a simple manner about the journals 10 of the two frame members 9 and can be readily connected with the members 9. The swinging of the transverse frame member 8 is effected after loosening the fixing screws 13, the lengths of the guiding slots 14 limiting the amount of swinging. As shown in Fig. 3 a forward rake of the wheel 1 is indicated by the line V, F being the direction of travel, and can be adjusted by swinging the transverse frame member 8 to any desired extent up to a rearward rack according to the line N. In Fig. 3 furthermore, 3 is the steering swivel and 2 the wheel axle. The lines V and N are axes of the steering swivel 3.

The link 4 is connected to the shock absorber 15 secured at the transverse frame member 8 and thus serves for transmitting the effect of the shock absorber to the wheel as well as for guiding the wheel. Further constructional details, the arrangement and mounting of the links and transverse spring and the securing of the shock

absorber are clear from the drawing and are also sufficiently well known.

What I claim is:—

1. Adjustable wheel suspension for varying the forward and rearward rake of independently swinging steering wheels comprising, a longitudinal frame, a transverse frame member journaled on said longitudinal frame, guiding links pivotably mounted on said transverse member and springs extending therefrom for suspending the transverse frame member on the wheels, said transverse frame member being rotatable about said journals, and means for securing said transverse frame member to said longitudinal frame in different rotated positions.

2. Adjustable wheel suspension for varying the forward and rearward rake of independently swinging steering wheels comprising, a longitudinal frame, a transverse frame member journaled on said longitudinal frame, guiding links pivotably mounted on said transverse member and springs extending therefrom for suspending the transverse frame member on the wheels, said transverse frame member being rotatable about said journals, means for securing said transverse frame member to said longitudinal frame in different rotated positions comprising a flange at each end thereof, each flange having elongated openings therein, and screws extending through said openings for securing each flange to the longitudinal frame whereby the rearward and forward rake of both wheels may be adjusted simultaneously by rotating said transverse frame member.

3. Adjustable wheel suspension for varying the forward and rearward rake of independently swinging steering wheels comprising, a longitudinal frame, a transverse frame member rotatably mounted on said longitudinal frame, guide links pivotably mounted on said transverse frame member, springs extending from said transverse frame member for suspending the transverse frame member on the wheels, auxiliary links pivotably mounted on said transverse frame member and all of said links being movable in the swinging planes of the wheels, said transverse frame member being rotatable to simultaneously adjust the rearward and forward rake of both wheels, and means for locking said transverse frame member in an adjusted position on said longitudinal frame.

OSCAR SIEBLER.

[Excerpts from "Vibration of Rail and Road Vehicles" by B.S. Cain, pages 84, 85 and 86—published in 1940]

$$+ \frac{-bn\cos nt + (\omega^2 - n^2)\sin nt}{n\{(\omega^2 - n^2)^2 + b^2n^2\}}\Bigg]$$

$$= \frac{F\sin(nt - \delta_1)}{\sqrt{(\omega^2 - n^2)^2 + b^2n^2}}$$

$$- \frac{Fn}{\sqrt{\omega^2 - \frac{b^2}{4}}} \frac{e^{-\frac{b}{2}t}\sin\left[\sqrt{\omega^2 - \frac{b^2}{4}}\,t - \delta_2\right]}{\sqrt{\omega^4 + n^4 + n^2(b^2 - 2\omega^2)}}$$

where
$$\tan\delta_1 = \frac{bn}{\omega^2 - n^2}$$

$$\tan\delta_2 = \frac{b\sqrt{\omega^2 - \frac{b^2}{4}}}{\omega^2 - \frac{b^2}{2} - n^2}$$

Example. Referring to the end of Chapter 2, let a spring-supported weight roll over a single low spot in the road. (See Fig. 66.)

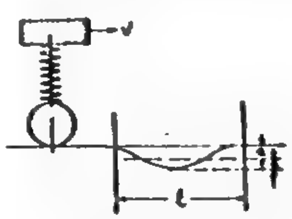


FIG. 66

Let $\omega_e = 2\pi \times$ natural frequency of vibration of the weight on the spring

$2a$ = depth of low spot

l = length of low spot

v = speed at which the weight rolls

y = downward motion of the weight below the original equilibrium position.

$$\omega = \frac{2\pi v}{l}.$$

Then $\dfrac{d^2y}{dt^2} + \omega_e^2(y - a\{1 - \cos\omega t\}) = 0$

or $\dfrac{d^2y}{dt^2} + \omega_e^2 y = \omega_e^2 a(1 - \cos\omega t)$

or $(p^2 + \omega_e^2)y = \omega_e^2 a \times \dfrac{\omega^2}{p^2 + \omega^2}$ from rule 9 (b)

$$y = \frac{a\omega_e^2\omega^2}{(p^2 + \omega_e^2)(p^2 + \omega^2)}$$

$$= \left(\frac{1}{p^2 + \omega_e^2} - \frac{1}{p^2 + \omega^2}\right) \times \frac{a\omega_e^2\omega^2}{\omega^2 - \omega_e^2}$$

$$= \frac{a}{\omega^2 - \omega_e^2}[\omega^2(1 - \cos\omega_e t) - \omega_e^2(1 - \cos\omega t)]$$

from 9(b)

$$= a - a\left(\frac{\omega^2\cos\omega_e t - \omega_e^2\cos\omega t}{\omega^2 - \omega_e^2}\right)$$

$$= a - a\left[\frac{\cos\omega t - \frac{\omega^2}{\omega_e^2}\cos\omega_e t}{1 - \frac{\omega^2}{\omega_e^2}}\right]$$

which applies from $t = 0$ to $t = \frac{l}{v}$

when $t = \dfrac{l}{v}$,
$$y = a - a\left[\frac{1 - \frac{\omega^2}{\omega_e^2}\cos 2\pi\frac{\omega_e}{\omega}}{1 - \frac{\omega^2}{\omega_e^2}}\right]$$

$$\frac{dy}{dt} = -a\left[\frac{\frac{\omega^2}{\omega_e^2}\sin 2\pi\frac{\omega_e}{\omega}}{1 - \frac{\omega^2}{\omega_e^2}}\right]$$

After the weight has passed over the low spot, the equation of motion is

$$\frac{d^2y}{dT^2} + \omega_e^2 y = 0$$

and we will now measure the time, T, from the moment the weight passes the end of the low spot. Then the auxiliary equation is, from (12)

$$(p^2 + \omega_e^2)y = p^2 U + pv$$

$$\therefore\ y = \frac{p^2}{p^2 + \omega_e^2} U + \frac{p}{p^2 + \omega_e^2} V$$

$$= U \cos \omega_e t + \frac{v}{\omega_e} \sin \omega_e t \quad \text{from 11 } (b) \text{ and 10 } (b)$$

where
$$U = a\left[1 + \frac{-1 + \dfrac{\omega^2}{\omega_e^2} \cos 2\pi \dfrac{\omega_e}{\omega}}{1 - \dfrac{\omega^2}{\omega_e^2}}\right]$$

$$v = -a\omega_e \left[\frac{\dfrac{\omega^2}{\omega_e^2} \sin 2\pi \dfrac{\omega_e}{\omega}}{1 - \dfrac{\omega^2}{\omega_e^2}}\right]$$

Several Degrees of Freedom. Equations with several variables are handled in just the same way as above, for example if the equations are:

$$(a_{11}p^2 + b_{11}p + c_{11})y_1 + (a_{12}p^2 + b_{12}p + c_{12})y_2 = S_1$$
$$(a_{21}p^2 + b_{21}p + c_{21})y_1 + (a_{22}p^2 + b_{22}p + c_{22})y_2 = S_2$$

the auxiliary equations are:

$$(a_{11}p^2 + b_{11}p + c_{11})y_1 + (a_{12}p^2 + b_{12}p + c_{12})y_2 =$$
$$(a_{11}p^2 + b_{11}p)U_1 + a_{11}pv_1 + (a_{12}p^2 + b_{12}p)U_2 + a_{12}pv_2 + S_1$$
$$(a_{21}p^2 + b_{21}p + c_{21})y_1 + (a_{22}p^2 + b_{22}p + c_{22})y_2 =$$
$$(a_{21}p^2 + b_{21}p)U_1 + a_{21}pv_1 + (a_{22}p^2 + b_{22}p)U_2 + a_{22}pv_2 + S_2$$

These simultaneous equations are solved for y_1, and y_2 and the resulting functions of p are interpreted according to the rules given above.

TRANSCRIPT OF PROCEEDINGS

Washington, D.C.
Tuesday, March 3, 1964

The above-entitled matter came on for trial at 10:00 a.m. before the HONORABLE JOSEPH R. JACKSON, Judge, United States District Court.

APPEARANCES:

On behalf of the plaintiff:

EDWIN S. BOOTH, ESQ.
Bair, Freeman & Molinare
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Chicago 3, Illinois

N. D. PARKER, JR., ESQ.
1518 K Street, N.W.
Washington 5, D.C.

On behalf of the defendant:

JOSEPH F. NAKAMURA, ESQ.
Solicitor's Office
U. S. Patent Office

3 THE DEPUTY CLERK: Civil Action Number 1059-63, Kenneth E. Lyman versus David L. Ladd, Commissioner of Patents.

THE COURT: Are the parties ready?

MR. PARKER: Yes, Your Honor.

MR. NAKAMURA: Ready, Your Honor.

MR. PARKER: If Your Honor please, my name is Parker and I am the local associate. I would like to introduce Mr. Edwin S. Booth of Chicago. He is a member of this Court and he will conduct the argument.

THE COURT: You are a member of this Bar here?

MR. BOOTH: Yes, sir.

I had the pleasure of passing the Bar Examination here before I moved to Chicago, Your Honor.

THE COURT: I see.

MR. BOOTH: At the outset I would like to offer as plaintiff's ex-

hibit 1 a certified copy of the file history of the Lyman application here-involved.

THE COURT: Mark it in evidence.

THE DEPUTY CLERK: Plaintiff's Exhibit Number 1 is marked in evidence.

(Plaintiff's Exhibit No. 1 was received in evidence.)

MR. NAKAMURA: I offer the defendant's exhibit number 1, Your Honor.

4 THE COURT: Are you familiar with that?

MR. BOOTH: Yes, Your Honor.

THE COURT: Mark it in evidence.

THE DEPUTY CLERK: Defendant's Exhibit Number 1 is marked in evidence.

(Defendant's Exhibit No. 1 was received in evidence.)

THE COURT: I have been looking over your brief, and you know, many, many years ago I taught mathematics in high school, but this is beyond me. So I will have to be taught a lot about mathematical apportionment and things of that character.

MR. BOOTH: We will try, Your Honor. We have Dr. Lyman here, who will be a witness in the case, and he will do most of the explaining of it to the Court. We have some little models with which we can demonstrate the principles involved, and we hope we will be able to explain it satisfactorily.

THE COURT: Well, they say a picture is better than the written word, so maybe these tangible exhibits will be better than words.

MR. BOOTH: I hope so, Your Honor.

THE COURT: I hope so too.

OPENING STATEMENT ON BEHALF OF THE PLAINTIFF

MR. BOOTH: Your Honor having read the brief you are familiar
5 with the fact that we are involved here with a wheel suspension system. This is an unusual case in that we are not concerned with changes in the structure of the system, but with a particular mathematical apportionment or relationship of the mechanical components and the spring components which make up a conventional suspension system.

If Your Honor please, I would like not to try to explain it at this time but to leave that for Dr. Lyman when he is on the stand. The Patent Office rejected all of the claims on the basis of a Metz patent. For some of the claims it also combined with Metz a Siebler patent and a publication entitled "Vibration of Rail and Road Vehicles." It is quite clear, however, that the Siebler patent and the publication are purely secondary and that the issues hereinvolved revolve solely around the Metz patent.

THE COURT: I notice the cases cited are on anticipation. Now the Metz patent is not an anticipation, is it?

MR. BOOTH: The Patent Office held that the teaching in Metz was the equivalent of Dr. Lyman's mathematical apportionment.

THE COURT: I see.

MR. BOOTH: But whether that is anticipation or lack of invention under Section 103, I am not really sure.

We can agree at the outset, Your Honor, that so far as the
6 structure is concerned, the structural elements are shown in Metz, or the Patent Office could have selected any one of a number of other patents to show the structural elements.

THE COURT: The elements are old then, but it is the juxtaposition and construction that makes it patentable?

MR. BOOTH: That is correct.

The sole novelty here and the sole issue involved is this particular relationship of the elements which produces some results that we think are rather remarkable. The Metz patent is relied on—

THE COURT: Did I see something about shock absorbers here? Does it mean that your construction does away with the need for them?

MR. BOOTH: That is correct. It not only does away with the necessity of them but it actually demands that they be removed. Instead of being necessary, as they are on present systems, they would be an actual detriment. The Metz patent was relied upon because it proposes to equate the frequency of motion of the mechanical elements of the suspension system with the frequency of motion of the spring elements of the system.

The Patent Examiner and the Board of Appeals both held that this purported equating of frequencies was the full equivalent of Dr.

Lyman's mathematical apportionment. The difficulty with that is that
7 there is no such thing as the frequency of the mechanical suspension elements. We have these arms that are projecting out horizontally with the wheel connected to the end of them. The only force acting—

THE COURT: That would be a separate axle for each wheel?

MR. BOOTH: Yes, that is the independent suspension which is very commonly used today, Your Honor. The same thing would be true, however, of a solid axle, except that we don't find many solid axles any more.

Regardless of whether it is an independently suspended wheel or a solid axle, we do have this mass that is supported on horizontally extending supporting structures or linkages, and the only froce acting on that mass is the force of gravity, which is a constant force tending to move it downwardly. I think we will be able to demonstrate this to Your Honor with models a little later on. So that it is completely impossible under those conditions for the mechanical elements of the suspension system to have a frequency.

THE COURT: What is the benefit of the construction you have in the application to the rider of the car?

MR. BOOTH: To the rider of the car it does three things basically. First, it enables the wheel to recover more rapidly so that it maintains tire-road adhesion. This leads to very much improved control of the
8 car and very much improved safety.

THE COURT: Would that answer for a hole in the road?

MR. BOOTH: Yes, Your Honor.

THE COURT: I mean where the asphalt or whatever the surface covering is leaves a hole.

MR. BOOTH: Yes, sir.

THE COURT: And where they put something over it that makes it very rough.

MR. BOOTH: Yes, sir. This principle applies and is advantageous whether the wheel goes over a rise, a bump, or whether it falls into a depression.

THE COURT: I see.

MR. BOOTH: The principal thing we are concerned with is rapid recovery of the tire to contact with the road after it has been bounced.

THE COURT: Did you say balanced or bounced?

MR. BOOTH: Bounced.

With the conventional system when the tire bounces over a bump or goes into a depression and comes out of it, it leaves the road surface and there is a definite time of recovery for the tire to regain contact with the road surface. The shorter that time can be made the better it is. This is what we mean by tire-road adhesion. If the tire
9 maintains continuous contact with the road we have 100 per cent tire-road adhesion.

Now the other advantage to the driver of the car is comfort. When you hit a bump in a car, of course the wheel must go up. There is no choice, it has to go up. The distance it goes up and the rate at which it goes up depends on how fast the car is going and how high the bump is. The wheel simply has to go up that distance less whatever part of that the tire itself may absorb, which we will disregard here for our purposes today.

With a conventional system, suspension system with a shock absorber, the shock absorber resists upward movement of the wheel and it transfers that force to the frame and causes the frame to move so that the passengers feel the bump. If the wheel were free to move up, if it were not restrained, the passenger would not feel that force at all.

Now with this system the wheel is free to move up except for the change in spring force because of the rise of the wheel. This is a very small change for almost any driving condition. So passenger comfort is very greatly improved. I think, however, the most important thing is the improvement in the tire-road adhesion and the safety and control which results from that.

Now I am saying that the Metz patent relies on equating the
10 frequency of the mechanical parts with the frequency of the spring elements of the system. And the difficulty we find with Metz in that respect is that there is no such thing as a frequency of the mechanical parts. It simply cannot exist under the natural laws of physics and mechanics. We think Metz was wrong when he said it existed and that the Patent Office Examiner and the Patent Office Board of Appeals were wrong when they accepted Metz's statement.

So the issue here really is an issue of laws of whether or not the patent laws can disregard the natural laws of physics and mechanics. We say that they cannot and that, therefore, Metz does not teach or suggest—

THE COURT: Well, of course, you can't ignore natural laws. That is quite correct. Whether or not it does will depend on what we hear.

MR. BOOTH: Yes, Your Honor. We think that it does, that the statement cannot exist under the natural laws and that, therefore, there was error in denying the claims.

Thank you, Your Honor.

THE COURT: Was the case tried below on this very theory?

MR. BOOTH: Yes, Your Honor.

THE COURT: And were all of these arguments presented to the Board and the Examiner?

11 MR. BOOTH: I can't say that all of them were. I can certainly say that the major ones were.

THE COURT: Did you prosecute the case?

MR. BOOTH: Yes, Your Honor.

THE COURT: Do you wish to be heard now, Mr. Nakamura?

MR. NAKAMURA: I would like to make a short statement, Your Honor.

THE COURT: Very well.

OPENING STATEMENT ON BEHALF OF THE DEFENDANT

MR. NAKAMURA: May it please the Court. The Metz patent on which the Patent Office principally relies shows an independent front wheel suspension system.

THE COURT: Did it ever go into commercial production, do you know?

MR. NAKAMURA: I am not aware of that fact, Your Honor, if it has, but I believe the patentee indicates that it has been made.

THE COURT: Made and being used are two different things though.

MR. NAKAMURA: Yes, sir.

Now Metz discloses that he eliminates unbalanced forces by using a spring having an established frequency and by proportioning the suspension length and radius arm in accordance with the spring

12 frequency.

Now it is the position of the Patent Office—and this was expressed by the Board—that when Metz did these things he apparently obtained what is called for in the claims, namely, the same rate of downward movement for the spring and the suspension elements. In that respect is the plaintiff's invention defined. And that is about all I would care to say at this time, unless Your Honor would like to have me go into more details.

THE COURT: Call your witness.

MR. BOOTH: Dr. Lyman.

Thereupon—

DR. KENNETH E. LYMAN,

the plaintiff herein, was called as a witness in his own behalf and, having been first duly sworn, was examined and testified as follows:

MR. BOOTH: Your Honor, before I start examining Dr. Lyman I might answer the question you asked about whether the Metz structure was ever built. There were several structures built in connection with which Dr. Lyman cooperated with Metz and he will tell you all about that.

THE COURT: All right.

DIRECT EXAMINATION

BY MR. BOOTH:

13 Q. Will you state your name and address for the record? A. Kenneth E. Lyman, Hinsdale, Illinois.

Q. What is your education, Dr. Lyman? A. I like to divide my education into two distinct phases. First is the academic. I secured a BS degree in Mechanical Engineering from Lewis Institute in Chicago, which is now a part of the Illinois Institute of Technology. During World War I, because of the work performed, I was awarded but never conferred the degree of ME by the Victorian University of Manchester, England. And because of the work that I did on aircraft I was awarded a Doctor of Science degree by Oxford University.

Now with relation to the education, I have given several lectures in a number of universities, and I opened my lectures quite often by stating that all the people there are dumbbells and that is the reason they are there, they have to be taught, whereas there is only one point of knowledge which is beneficial to mankind, and that is the practical

experience which one accumulates by practical work.

THE COURT: That is being educated by doing.

THE WITNESS: Educated by doing is right. And in my activities it has been unchanged since I was about ten years old, the first time I decided to go into the automotive business from the mechanical stand-
14 point. And I have been active on a number of suspension problems and power plant problems, including transmissions, carburetion and engine structure itself.

I have been rather fortunate in that I got bunged up in an automobile race and when I came out of that race I had to limit my activities to thinking and direction rather than actually doing it myself.

THE COURT: You were a young man, I assume, then?

THE WITNESS: I was very young at that time.

THE COURT: That is a young man's game.

THE WITNESS: Yes, Your Honor, that is a young man's game. I am still young, and I am going to continue to be that way all the time. But I first played around with a spring prior to going to college. That spring was a spring called the cantilever spring, where I used the two forces with the spring where the spring action accomplishes this in response to road travel. The first is a deflection and against a supporting part on the chasse. And the second is the extension of the spring or toggle like action of the spring when the camber flattens out. And I used that second force to change the position of the anchorage to the frame so that when you hit a bump the spring anchor position shifted in response to the amount of the deflection of the spring.

After—I am not accustomed to this here.

15 THE COURT: Do you need some water?

THE WITNESS: No, sir. I use that for two purposes.

BY MR. BOOTH:

Q. Do you want to tell us something of your practical experience after you left college, Dr. Lyman? A. After I got out of college I came up to Detroit and entered employment with the Cadillac Motor Company, in which case I worked for about three weeks each in two separate sections which had to do with the design of automotive parts. And I was transferred from there to their experimental department, and three weeks after I was in the experimental department I was made

the head of the Cadillac Experimental Department.

In the Experimental Department of Cadillac we ran continuous tests on car springs and the functioning life and capabilities of various types and forms of spring structure. These were destruction tests run by machines. And I also engaged in all of the other activities that are essential to production of automotive parts.

After being with Cadillac World War I was declared. I came back and spent three months with Mitchell Motors where I did considerable work on springs, particularly with relation to the bushings which support the pivotal action at the ends of the spring. And when I got into the service, which was in October or November of 1917, I went
16 to ground school and was transferred out of there as an instructor and from there went to England where I became within ten days of arrival I became a member of the Technical Section, Motor Section, U.S. Army Aviation. In that I set up the systems which were used in the overhaul of the aviation engines of that time. And I also worked in liaison with the British Technical Section and with the French Technical Section representing the American Technical Section, Aviation.

Q. And after leaving the Army what did you do? A. After leaving the Army I had done some considerable work on combustion as one of the lines of interest and I became chief engineer of Currey Lyman Steam Automobile Company in Topeka, Kansas, where we built thirteen steam automobiles. About that time I found out that while I might be satisfactory as an engineer I didn't know anything about business, and that organization failed.

Returning from Kansas to Chicago I became Professor of Mechanical Engineering at the DePaul University, Chicago, Illinois, which position I held for two years. In that, like you, Your Honor, I taught mathematics; and I taught both in the academy and also in the college. And I think maybe my knowledge is the same as yours at the present time.

THE COURT: Well you kept yours up probably in advance of the times; I didn't.

17 THE WITNESS: No, I can't say that I kept it up. In my future occupation, which I will mention shortly, I found it desirable to have a staff functioning for me who were all specialists on their particular

lines of activities. Therefore, my actions became more directive rather than doing the work myself. I mean the physical work.

I resigned from this professorship which I occupied during the time when engineering work was hard to get and went with Mr. Vincent Bendix as his technical assistant. This is the Vincent Bendix who formed all the Bendix corporations. And in that business I provided liaison for all of the divisions Bendix then had. I acted in the investigation and the consolidation of the subsidiaries and other organizations and divisions of the Bendix Corporation. I had charge of all proposals made on any subject by any outside party to the corporation. And as such all of the inventers came to me and these matters passed through my hands and I functioned on those items which were recognized as valuable to the automotive industry by reducing them to commercial models ready for manufacture, and usually assigning them to that corporation division which was best qualified to produce them.

THE COURT: I think the doctor has more than sufficiently qualified himself to testify as an expert.

MR. BOOTH: If Your Honor please, I have here a brief resume of
18 his career. May I offer that as plaintiff's exhibit 2?

THE COURT: You may. I know there will be no objection, therefore, it may be marked in evidence.

THE DEPUTY CLERK: Plaintiff's Exhibit Number 2 marked in evidence.

(Plaintiff's Exhibit No. 2 was received in evidence.)

THE WITNESS: Your Honor, I might state that on that resume I set it up in different form than personal resumes are usually set up. I delineated the major activities in which I have participated.

BY MR. BOOTH:

Q. Dr. Lyman, can you tell us something of the history of wheel mounting mechanisms for automobiles? A. When the first production automobile was built, for reasons of convenience, the engineering with relation to the mounting of the wheels was very poorly done. These engineering defects and deficiencies have been carried throughout all of the production cars since that time.

THE COURT: Well, I suppose the original automobiles had the

wheels attached to the axles the same as buggies, did they?

THE WITNESS: The simply took—

19 THE COURT: The knowledge that they knew.

THE WITNESS: The knowledge that they knew. For example, the buggy, which was the original device used to mount the power plant on, had the swinging of the front wheels on the center line of the vehicle and the whole axle swung all around. But that didn't permit mounting the body on without interference of the wheel with the body. So instead of having a single kingpin pivot in the center of the axle they moved them to the side and used the straight through axle and then two separate swinging arms on which the wheels were mounted. And the further the distance between that pivot point or the shorter the distance between that pivot point and the center line of the wheel, that all represents a leverage which causes a reaction to occur back through the steering system. And as a result, throughout the years since that time, the inherent poor engineering is still present. And at the same time, when they recognized each of these incoming new forces they added not an answer to them but something to correct further mistakes which were designed in. So that at the present time on the 165,000,000 automobiles that have been built here in the United States—about 105, 000,000 in the United States and the rest in Europe—each of these devices haven't has as good engineering as they might. So to trace the path of the things that have happened, they found out that when they ran
20 over a bump they transferred that force directly into the vehicle. So they had to do something about it. So they put in what they called a shock absorber. First of all, it wasn't a shock absorber, they called it a snubber. And the snubber permitted free upward motion of the wheel. But on the down stroke it snubbed it by a friction effect which stopped it from attaining contact with the road.

In other words, any time you keep the wheel off of the road you are not getting as good control and as good traction.

THE COURT: Didn't the snubber react immediately after the bounce and go back into its original shape?

THE WITNESS: It came down but it was delayed in coming down. The wheel was delayed in coming down. In other words, it was free to move up with the snubber, but on the downward part, which is the only

part that you can control anyway because the bump and the speed of the vehicle controls the upper, it was delayed.

Now the objective should be to let the wheel move without transferring any force to the frame, which is accomplished with our procedures.

The snubber was followed by the shock absorbers. And the shock absorbers first were only for downward motion. Then they found it was cheaper to make the shock absorber work both ways. So they stopped the wheel from coming up and they stopped it from coming
21 down. Of course, those original shock absorbers didn't work too good. And as we improved the quality of the shock absorbers we found that the forces, when you hit a bump, would be transferred through the shock absorber directly into the vehicle. Whereas, if you take an apportioned engineering vehicle, when you go down the road, the wheels move up and down but the body stays right in the same plane, it doesn't move up and down at all, because the only force which is transmitted to the body is the change of spring deflection, which amounts to less than 100 pounds as compared with the inertia force of the body, which amounts to probably 1,500 pounds. Therefore, there isn't any detectable shift of the body up and down if you use the apportioned structure and thereby eliminate the shock absorbers.

BY MR. BOOTH:

Q. Dr. Lyman, I mentioned to the Court a moment ago that you had been instrumental in assisting in the building of some cars in conjunction with Mr. Metz, the patentee in this patent reference. Would you tell the Court about that, please?

THE COURT: There has been a Metz car, hasn't there, years ago?

THE WITNESS: Yes, there was a Metz car, and that was a friction drive car, if you will remember. And I knew that Mr. Metz too.

22 BY MR. BOOTH:

Q. That was a different Mr. Metz? A. That was an entirely different Metz.

Following my activities for Bendix I transferred over and became assistant to the President of Borg-Warner Corporation. And as per my duties handling all the inventers, I had a group come to me from

Davenport, Iowa, including a financial man and this man Metz. At that time Metz already had a patent or so on putting the kingpin on the center line of the wheel. I looked over what he had and I saw that it was technically a poor design on account of losses that the bearings had to operate at, and it was impractical on account of the size diameter of the bearings. I suggested to him that he forget about the straight axle because independent suspension was going to become universal in the automotive business. And he returned to Davenport and built, initially with small cooperation on my part, all told eleven vehicles. On the last three vehicles I worked closely with him and used what engineering knowledge I had to—

THE COURT: Were they build in accordance with the structure of his patent?

THE WITNESS: The last one was. Now I had nothing to do with Metz's setup with the exception that he brought the jobs to me and I
23 road tested them. I road tested Metz's jobs for approximately 165,000 miles. And each one of them, as in any engineering development, was better. Each one of the eleven designs was better than the preceding one because he eliminated defects which were apparent in the preceding one.

When he came to this last design that particular structure which is shown in Metz's patent was applied to my own personal car. That was the one that was built to fit my car. And I ran a lot of tests on it and the Borg-Warner group were active in it and one of the automotive companies placed an order for it. But then the automobile company was given orders to drop it on account of the pressure that was put on by shock absorbers, the shock absorber people and others. So the subject matter was dropped. The option contract with Metz was cancelled two years after Borg-Warner ceased all activity on the subject; and that was in 1939. I felt the structure was of sufficient importance to mankind that it should be followed through so I resigned from Borg-Warner and came up to Detroit and demonstrated the structure to Mr. Henry and Edsel Ford. Both of them drove it and Mr. Edsel Ford said this obsoletes everything that has ever been done, it provides the smoothness of riding, the comfort and the precise, positive steering control that is a desirable characteristic. At that time

there was no issuance of a patent. And so far as Metz's patents are
24 concerned, I knew the counsel that took them out, both the counsel at Davenport and the one in Chicago. But I had nothing to do with anything except the mechanical features that went into the structure. I didn't see the patent and I didn't know what was in it.

THE COURT: Well, Edsel Ford seemed to think it worked all right, didn't he?

THE WITNESS: Yes, he asked me to come back at the end of the war. He recognized it. He said, "Lyman, it is nice to see this structure, but there isn't anything we can do about it at the present time because we have Government directives for 24-hour conversion of our plants for war purposes." And I found that to be true with all the other automobile companies too. I made the rounds at my expense to show this because it had reached considerably over 100,000 miles on the one unit and it had to be junked. There wasn't any sense in keeping it so I do not have it at the present time. I do not have at the present time any of the elements that went into those models which, incidentally, that is years back, 1940.

THE COURT: Was that system put into commercial production?

THE WITNESS: That system never was put into commercial production.

THE COURT: I wonder why, since Edsel Ford liked it so much?

25 THE WITNESS: Well, you have got to bear in mind that the Ford Company had these Government directives at that time.

THE COURT: I know, but they didn't exist after the War was over.

THE WITNESS: But, unfortunately, Mr. Edsel Ford didn't exist after the War was over.

THE COURT: I know he didn't, but surely he had someone to take his place. He must have had a stand-in.

THE WITNESS: I will tell you that at the time that this was up the chief engineer of the Ford Company said to me, 'Ken, I will go out and look at this, but what can I do? "My complete staff amounts to thirteen people, including the boy who gets the blue prints." And after the War was over—that is World War II—or after the fighting stopped Edsel was physically incapacitated and Henry Ford was out of the picture, but he came back in later.

THE COURT: I had a notion you were talking about World War I but, of course, you were overseas then. I made a mistake. Go ahead.

THE WITNESS: This is World War II.

THE COURT: This was all World War II then?

THE WITNESS: No, sir.

THE COURT: You spoke about World War I. Weren't you with the
26 Government in World War I?

THE WITNESS: Yes, sir.

THE COURT: You were overseas, weren't you?

THE WITNESS: Yes, I was overseas. I gave a history after World War I.

THE COURT: I know but I haven't looked at this yet. The thing is you went from one to the other and you talked about Edsel Ford, and you talked about having Government commitments, and I assumed it was World War I. Go ahead though, it doesn't make any difference.

BY MR. BOOTH:

Q. Dr. Lyman, let's go back for just a moment. In constructing these cars which you worked on with Mr. Metz, how was the spring designed? A. We simply took the standard spring and modified the bottom leaf and used the standard spring furnished by the automobile company.

Q. What modification did you make? A. We only carried it out straight instead of having it rolled. That is insignificant with the exception that it provided a better way, in our opinion, of mounting the ends to the spring.

Q. Did it have any effect on the spring characteristics? A. None whatsoever.

27 Q. How did you design the linkage, the mechanical suspension linkage? A. First of all, on the original Metz jobs the inward pivots for the suspension links were at the center line of the car and it was a very short link, like this (demonstrating), for convenience, and then we had a stub axle carried Metz's cast center line steering. But we recognized that stresses in the early models that Metz made were high and improper, so we transferred that suspension linkage over so that it all could be very close to the outside of the frame.

In other words, we eliminated, in essence, the stub axle

which had been used.

THE COURT: Well, is your system just an improvement on the Metz system, or is it radically different? Your counsel stated that under the Metz system the natural law was violated.

THE WITNESS: Metz stated and apparently thought that the wheel mass had a frequency of up and down motion, and it is so stated in the Metz patents.

THE COURT: Well, has it?

THE WITNESS: It has no frequency. It can't have any.

THE COURT: The wheels, you are talking about?

THE WITNESS: Yes, the wheels. The front wheel and the rear wheel can't have any frequency of up and down motion. The spring has a frequency, but the mechanical structure—

28 THE COURT: The wheel per se, do you mean, but the wheel has it when it is attached to the body and the spring? Doesn't it move with the whole carcass of the thing?

THE WITNESS: In consideration you have to consider the wheel mass as one thing. The wheel mass and the spring are not necessarily fastened together.

In other words, there have been a number of cars in the past built where while using the straight leaf on the spring it is not tied to the wheel apparatus itself.

BY MR. BOOTH:

Q. Dr. Lyman, could you perhaps answer this more clearly through the use of models? A. Possibly; yes.

MR. BOOTH: Mr. Nakamura has seen these, Your Honor, and I have had this marked plaintiff's exhibit 3 and this model plaintiff's exhibit 4.

THE COURT: Mr. Nakamura has no objection, therefore, they may be received in evidence.

THE DEPUTY CLERK: Plaintiff's Exhibit Number 3, which is the model Thunderbird, is marked in evidence; and plaintiff's exhibit 4, which is a suspension demonstration model, is marked in evidence.

(Plaintiff's Exhibits No's. 3 and 4 were received in evidence.)

29 BY MR. BOOTH:

Q. Dr. Lyman, I hand you these two exhibits, plaintiff's exhibits 3 and 4. Would you like to use those in explaining the matter you were discussing?

THE WITNESS: You might sit down, Your Honor.

THE COURT: All right.

THE WITNESS: I can do this right here just as easy.

This here is a—

THE DEPUTY CLERK: Keep your voice up, please, so the reporter can take down everything you say.

THE WITNESS: In this model we represent the wheel by this structure here (demonstrating). The two arms here are the suspension arms and this is the chasse. Now there is no force on this at all with the exception of the force of gravity. There are no forces. There is no frequency of motion of the wheel mass and the suspension linkage. Now that is what Metz states he has. But he doesn't have it because he can't have it. That is against the natural laws. If Metz's statement were true we couldn't be here, because if there is an anti gravity law gravity couldn't exist. If this anti gravity law causes this wheel to move up, whereas gravity makes it fall, if the anti gravity effect actually exists, that would mean that all matter throughout the complete universe and even each element itself would automatically disintegrate.

30 THE COURT: But did he say anti gravity?

THE WITNESS: He didn't say anti gravity.

THE COURT: What did he say that makes you say that?

THE WITNESS: He said that here by the length of the arms he established a property of frequency of motion.

THE COURT: What did he mean by that frequency of motion, going up and down?

THE WITNESS: You have to have double direction.

THE COURT: Well, how does that do anything with respect to violating the natural law?

THE WITNESS: You can't.

THE COURT: A wheel does go up and down, doesn't it, going over a rough road?

THE WITNESS: Going over a rough road, but not as an inherent

part of the structure.

THE COURT: That is what I said.

THE WITNESS: There is no—

THE COURT: What you meant was that it had nothing per se, nothing with respect to the mass to which it is attached, but by itself it might have and, naturally, would have. A wheel goes up and down, sure it does.

THE WITNESS: A wheel goes up and down in response to the road.

THE COURT: Isn't that what Metz meant?

31 THE WITNESS: He means anti gravity. You cannot have a frequency up and down by changing the lengths of these arms.

THE COURT: You might change the rate though of vibration?

THE WITNESS: No, you don't.

THE COURT: In those links?

THE WITNESS: No, you don't change it.

THE COURT: I thought the longer the link the—

THE WITNESS: No, gravity works every time, gravity on this wheel mass.

THE COURT: Go ahead.

BY MR. BOOTH:

Q. Could you, perhaps, Dr. Lyman, demonstrate what you mean by frequency by showing the Court how this would act as a pendulum? A. Yes. Now this is frequency. You see, that swings back and forth (demonstrating). That is a pendulum. Now a pendulum has a frequency.

THE COURT: Well, of course, that is not the nature of a wheel.

THE WITNESS: Well, a wheel has—

THE COURT: Or a vehicle.

THE WITNESS: No, a wheel never operates on a vertical road. There isn't anything such as a vertical road except—

32 THE COURT: The road to Heaven, maybe.

THE WITNESS: Well, I don't even know about that. I am not experienced in it yet.

THE COURT: Neither am I. I said maybe.

THE WITNESS: Now this here has frequency because a spring has a natural frequency of functioning up and down. But as long as this

wheel is suspended with the horizontal suspension arms you can't have frequency. Yet Metz states that he does have that property. And that is the point upon which this case rests.

THE COURT: I see.

BY MR. BOOTH:

Q. Dr. Lyman, I believe you made the statement that changing the length of those suspension arms would not have any effect on the rate of downward movement of the wheel. Did you ever try changing the length of the arms in any vehicle suspension systems? A. Yes. Metz changed the length of the parallelogram, which was illustrated in the patent, several times.

Q. What difference did it make? A. There was no detectable difference at all because the wheel mass has to move.

Now, as long as your memory on mathematics is as good as mine, Your Honor, I would like to suggest that for some length of time
33 I thought that this frequency of a pendulum also was true if it were out horizontal. But it isn't, it isn't at all. As a matter of interest, in the event we have the wheel functioning like a pendulum, that frequency would vary because the wear of the tire would mean that the mass hanging down on the pendulum would change. Or if it got splashed up with mud it would change. Therefore the frequency would change, because that is the way you control a car.

THE COURT: Now tell the Court how you have improved on that patentably on the Metz system; what have you done now?

THE WITNESS: Well, Metz says that the lengths were tried out between 14 and 16-inches. But that doesn't mean anything because that doesn't tell anybody how to make them both work.

THE COURT: How do you do it?

THE WITNESS: I do it my mathematical apportionment.

THE COURT: Tell me about it.

THE WITNESS: All right.

THE COURT: Mathematical apportionment is just two words to me.

THE WITNESS: Those two words mean that if you locate your pivot points—assuming that you start out with a spring of the proper frequency—and under those circumstances the spring has by design a
34 specific frequency. All automobile springs have that frequency. For

example, if you want to know the frequency of the spring on your automobile all you have to do is to stand up on your bumper and move up and down, bounce up and down, and you will find that the vehicle will move up and down as long as you move up and down at the frequency of the spring. And by counting the number of up and down motions and timing it you know then what the frequency of that specific spring is. But trying to do that at any other time or any other frequency the thing will just freeze up on you, and that is a condition of force fighting between a force of one frequency and a force that wants to function at another.

Now if you have a pendulum then you have a mass down here just like the pendulum on a clock. Now that is true if it is suspended in this position (demonstrating), but the instant that you bring it around so that this (indicating) is horizontal beyond the suspension arm, under those circumstances there is no frequency there at all; absolutely none, only the weight of the wheel and the end assembly and part of the weight of the links. Those are all dead weight and they follow the law of gravity.

Now you asked about what mathematical apportionment is. Now if you have that wheel mass functioning under the law of gravity and under the acceleration of gravity, then your spring, in order to move the same distance in the same length of time, has to have a cor-
35 relating frequency.

Now to attain that frequency, assuming that you start with your spring with a definite frequency, then you change the length of this arm (demonstrating) so that the distance of motion on this swinging arm where the spring is attached moves the same distance in the same length of time as the spring moves. And by having them together, you don't have any residual forces or other effects which have to be dampened out by a shock absorber. They don't exist. And this actually from the standpoint of ease of control and safety is one of the most important automotive inventions that has happened for some length of time.

Now I would like to comment on this safety factor. In driving an automobile loss of control of the car is the most important—

THE COURT: Do you mean without human error?

THE WITNESS: Yes, human error reflects in how the car goes down the road. Now you take your automobile and you drive it for one of these blocks with your hands off the wheel and find out how many times you will automatically correct for the steering being off in each block. And with this suspension, the maximum distance that I ever drove at 50 miles an hour with my hands off the wheel was 6 miles without any wobbling. Then again, you take the conventional automobile and
36 you drive down the road and you have somebody come in from the side or some obstruction that you have to clear, you would have to swing your steering gear so that you swing it further in order to get it into the position you want and then you have to correct it. Every time you make a turn in your automobile you swing the wheel and then you have to come back and correct for it because that is what we call over steering.

Now that is an inherent thing which results from the designed in features in the present production kind of suspension. But when you can take a job out and drive 6 miles with your hands off the wheel and have—

THE COURT: I wouldn't do it. I think anybody is crazy to do it.

THE WITNESS: Well—

THE COURT: What they had better do is send for the undertaker or family physician.

THE WITNESS: If you do the same thing with your car—You take your present car out and you take your hands off the wheel for one block you will see what happens.

THE COURT: I know.

You can do that with your system, do you mean?

THE WITNESS: It has been done.

THE COURT: You can't do it with a conventional system though?

37 THE WITNESS: No, you cannot.

What I am trying to say is you increase the safety.

THE COURT: How do you go around a corner?

THE WITNESS: Oh, by turning the wheel.

THE COURT: Do you mean on a straight road?

THE WITNESS: Well—

THE COURT: On a straight road you drove 6 miles with your

hands off the wheel?

THE WITNESS: That is right. And you cannot drive a half a block with any conventional present production automobile. You can't do it because it wanders. And that is a hazard to safety. Those are all characteristics which come in by taking out the designed in loading on the suspension structure characteristics, which, of course, includes steering along with it because that is part of your car control.

BY MR. BOOTH:

Q. Dr. Lyman, in talking about your mathematical apportionment you talked about downward movement of the wheel. What is the importance of balancing these forces during downward movement? A. Well, when the mechanical elements and the spring elements move together in coaction the same distance and at the same time. Under those circumstances, why you have no residual forces to cause you any trouble.

38 Q. What would happen if you put a shock absorber on? A. It would upset and you would have a lot of residual forces.

Q. What happens during upward movement of the wheel with your mechanical apportionment system? A. Well, if a suspension has freedom of upward motion of the wheel all the forces of the road gravity are taken in the mass motion upward of the wheel with the opposing lo loading of the spring deflection. Those are the only two loadings on the upward motion of the wheel. But if you have a shock absorber in there then you transfer part of that upward mass motion into the vehicle and you tip it. In some cases that is one of the reasons that cars roll over on the road. If your wheel goes up by itself you are just the same. You are sitting there in the car and you are going down the road and the wheel only moves up. The side of the car doesn't move up because that shows poor design.

Q. Can you explain to the Court the difference between your mechanical apportionment and this equating of frequencies that Metz talks about? A. Well, I don't know how to equate something with nothing. And Metz is talking about an absent quantity, something that doesn't exist. The mass, setting this here (demonstrating), that has no inherent frequency for up and down motion. It can't have it as an up and
39 down frequency on a suspension system because you have this mass out

over here (demonstrating) at this distance. There is no frequency of motion up and down and you have to have up and down motion. This here is solely a question of recognition of the fact that we have immutable physical laws for which there is no deviation. But Metz states that his design has that property, and that property doesn't exist.

Q. Dr. Lyman, have you kept up with the literature with respect to vehicle suspension systems throughout the years? A. Well, I regret to say that this has been a hobby with me. I have all the information on all of the foreign makes, on all of the American makes, and I have access to information on a lot of experimental work that is being done at the present time.

Q. Have you had occasion to study an appreciable number of patent relating to wheel suspension systems? A. I have the complete patent file of all the American patents issued. I have all the foreign patents that have been issued. And I know about fifty per cent more attempts have been made by various groups of trying to arrive at a better solution.

Q. From this study of the literature and the patents, and from your experience, have you ever seen anywhere a teaching or a suggestion of the use of mathematical apportionment? A. It is unfortunate that the engineers and the people in control haven't gone into the problem, the causes of the problem. They have only gone into the correction of the defects that exist. And that is the conventional practice which has been followed throughout the automotive industry. At the present time in some of the major automobile manufacturers they have three or four groups all working on suspension problems and all working on the correction of the defects that exist, but none on the elimination of the cause of the defects. And this here, in addition to being adherence to the natural laws, also is directed towards eliminating the cause of the defects. If you eliminate the cause of the defects the defects don't exist.

THE COURT: The defects are symptoms of the condition.

THE WITNESS: The defects result from poor engineering.

MR. BOOTH: You may cross-examine, Mr. Nakamura.

THE COURT: The Court will now take its usual morning recess. Court now stands in recess until 11:30.

THE DEPUTY MARSHAL: This Honorable Court now stands recessed until 11:30.

(Whereupon, at 11:10 a.m. the Court recessed as noted.)

41 After Recess

11:30 a.m.

THE DEPUTY MARSHAL: Will you resume the stand, sir. You are still under oath.

MR. BOOTH: May it please the Court—

THE COURT: May I interrupt you for a moment?

MR. BOOTH: Surely.

THE COURT: Doctor, I have had called to my attention something I hadn't observed before, the decision of the Board of Appeals on your petition for reconsideration. They say:

"We have carefully reviewed the disclosure of the Metz patent in the light of the errors alleged in this petition but remain of the conviction that our decision is free of error. Assuming, arguendo, that Metz's scientific explanation of the invention is unsound, the fact remains that, as in the present case, Metz proportioned his spring and the effective mass at the wheel so that downward movement of the wheel and of the spring will occur in a common period, that is, the spring and the wheel will have substantially equivalent frequencies of functioning as described by Metz and thus eliminate resultant or unbalanced forces and obviate the necessity of shock absorbers."

How do you claim that that is wrong? What has your system done that is different? Now regardless of patents or anything else, what has your system done that is different from Metz? What has
42 your device that is different from what is said here?

THE WITNESS: I will have to refer to Metz in making this statement.

THE COURT: Well go ahead and make it.

THE WITNESS: Metz states that he has abrogated, he has wiped out the law of gravity, because he says it has a frequency of action. And if he can do that, I don't know how he can—

THE COURT: Well, Edsel Ford must have thought he did a mighty good thing when he rode in that car with you.

THE WITNESS: Yes, sir.

THE COURT: That was built by Metz.

THE WITNESS: It was built by Metz but still I don't know that that had mathematical apportionment on it. Metz does not teach anything that would permit anybody to duplicate it.

THE COURT: Well, I will say this to both counsel, this is something that will have to be explained largely in your briefs which I will require after the trial is finished.

MR. BOOTH: If Your Honor please, although I indicated that I had finished my direct, we felt during the recess that perhaps we hadn't made this too clear to the Court, and I would like to make another attempt, if I may.

43 THE COURT: Go ahead.

MR. BOOTH: First, I would like to ask Dr. Lyman a question or two about the Metz patent and this construction.

THE COURT: The Metz device.

MR. BOOTH: The Metz device that was shown to Edsel Ford.

BY MR. BOOTH:

Q. Dr. Lyman, the Metz patent shows a shock absorber, does it not? A. Yes.

Q. Did the device that you showed to Edsel Ford have a shock absorber in it? A. Yes.

Q. You have already indicated that you don't know whether it had mechanical apportionment or not, is that correct?

THE COURT: What?

MR. BOOTH: Mathematical apportionment. I beg your pardon.

THE WITNESS: No, I do not know.

BY MR. BOOTH:

Q. If you were to undertake today to duplicate what was involved in that structure and to work out the design from the teaching of the Metz patent, could you do it? A. I could not, nor no one could, because Metz
44 teaches the existence of something that doesn't exist.

Q. In other words, you would have no way of calculating this frequency of the mechanical elements? A. None whatsoever.

Q. Now, Dr. Lyman, through these sketches on the board, could you explain to the Court in simple terms and as clearly as possible just

exactly what mechanical apportionment is? A. This structure shows a frame here of an automobile with wheels parallelogram linkage out to the wheel and the spring applied to that. In other words—

THE COURT: The spring is attached, is it?

THE WITNESS: The spring is attached to the frame and includes—

THE COURT: At both ends?

THE WITNESS: It could be. It makes no difference.

THE COURT: Or is it just pressured down?

THE WITNESS: Pressured down. You have pressure down always because in this position you must bear in mind that you have the static weight of the car for the horizontal position and, therefore, the road here is exerting a reaction equal to—

THE COURT: Would that be your device or the Metz device? What is it?

THE WITNESS: This is to explain what mathematical apportionment means.

45 THE COURT: Go ahead.

THE WITNESS: Expressed in terms of the mechanics.

Now this spring here (indicating) is duplicated here as shown in this form, and if this were drawn down it would spring up, so that you have the frequency of action. You also have a parallelogram, or you could put one member through to the center and have a mass here (indicating) equal to that. In other words, this single lever here pivoted here with a mass on here, due to road action, would move up and down. Now—

THE COURT: Action and reaction are what?

THE WITNESS: The action—

THE COURT: They are in opposite directions, aren't they? I would say they are equal in force and opposite in direction.

THE WITNESS: Yes. Now if this motion is at this angular distance (indicating), if this spring here at the point of application moves this distance (indicating), then by mathematical apportionment is selection so that the wheel motion under the same conditions is determined by the distance from one line here (indicating) to this line here. So that is what mathematical apportionment is.

THE COURT: I understand that. That is why I said it is contained

in those words I suggested to you, action and reaction are equal in force and opposite in direction.

46 THE WITNESS: No, the free motion of the wheel—

THE COURT: That is what it is, isn't it, action and reaction of that spring?

THE WITNESS: You have a force going down—

THE COURT: Well, you have a force going down to press it down, for instance, and it naturally comes back again.

THE WITNESS: No.

THE COURT: If you let it go?

THE WITNESS: No.

THE COURT: The spring?

THE WITNESS: Oh, the spring.

THE COURT: That is what I am talking about.

THE WITNESS: The spring, yes. The spring does, but not the wheel mass.

THE COURT: All right.

BY MR. BOOTH:

Q. Is there any peculiar relationship so far as the rate of movement of the spring and the rate of movement of the wheel and linkage under the action of gravity are concerned? A. Both function under separate laws. And this design is a practical design so that we take the desired limits of motion as a basis for the completion of the travel on the road. In other words, by taking the maximum normal motion and using that as the limits for the mathematical apportionment and seeing
47 that they operate under different laws, we arrive at a practical solution.

Q. What would happen if the spring tended to move faster than the wheel mass? A. You would have a residual force to the spring.

Q. Would you then have mathematical apportionment? A. No.

Q. Then as I understand what you are saying, the spring and the wheel mass must move separately in accordance with the natural laws which govern them individually? A. That is right.

Q. Through the same distance in the same time interval? A. That is right.

Q. And would you say that that is a fair definition of mathematical

apportionment? A. Yes.

Q. Now one more thing, Dr. Lyman. We have introduced a model exhibit 3 to which we have not referred. Would you just explain briefly to the Court what that model demonstrates? That is the model of the little plastic car, Your Honor.

THE COURT: Oh, yes.

You remain seated. I will walk over there. It will be easier for you. And talk into the microphone. Just sit down there.

48 THE WITNESS: When the question of having a model to show the Court came up I got the individual that makes all these fine models for Fisher and told him what the requirements were and he made this model.

THE COURT: Referring to exhibit 3.

THE WITNESS: Which has an up and down motion of greater distance than actually on the car. This model is 1/26 and 7.75 sizes. So he made this model, and this is the mechanical part of the linkage (indicating) showing a parallelogram located substantially on the center line of the wheel, and the spring effect is separate. That produces the showing that the two are separate entities in their functioning relationship. It is a cute little model.

THE COURT: I see.

MR. BOOTH: You may cross examine.

CROSS EXAMINATION

BY MR. NAKAMURA:

Q. Dr. Lyman, there is one point I wonder if you would clarify. Did I understand correctly that there is a balance of reaction forces when the spring and the mechanical suspension elements in your system have the same rate of downward movement? A. Substantially the same practically; yes.

Q. You said there was a practical balance of reaction forces? A.
49 Yes. I also said that they function under different laws.

Q. Yes. Dr. Lyman, with reference to the application drawing, defendant's exhibit 1-D—

THE COURT: On which page.

MR. NAKAMURA: This is exhibit D on page 2.

THE COURT: Yes, I see it. I was looking at the plaintiff's exhibit 1.

BY MR. NAKAMURA:

Q. Dr. Lyman, I would like to call your attention to figure 5 and ask you this question. You have shown S/2 and S/2? A. Yes.

Q. That would indicate then the total deflection that your wheel undergoes, the sum of the two, S/2 plus S/2? A. If you look into the patent application we specify the functioning limits on several pages of the patent application. And we show this as representative of what you can— So that you can understand the principles involved.

Q. But the symbol S stands for— A. Half the maximum limit of motion.

Q. Of what motion? A. Of the spring motion under suspension activity. In other words, when you take the bottom point S/2, that is the point of static loading; as I remember it.

50 Q. Then do I understand correctly that would be the same distance through which the wheel suspension elements would move at the point contacted by the end of the spring? A. There are two conditions of road travel which must be taken care of. One of them is a static position on a level road where the S/2 is above. And the other condition is dropping into low where that is S/2 downward.

Q. Dr. Lyman, you indicated that you have equal rates of downward movement of the wheel and suspension elements on the one hand and the spring on the other. How do you reconcile that in your answer? A. If you will read the specification you will see that that is covered at length on about a page and one-half of the specification.

Q. Dr. Lyman— A. You bear in mind that on these drawings that you were referring to you must assume that the horizontal line is that of a static loaded position, and that under those conditions the spring deflection would be equal to that established by the actual vehicle load under static conditions.

Q. Well, let me put the question another way, Dr. Lyman. The
time that your wheel would take say to drop a certain distance would
depend upon what factor, according to your mathematical apportion-
51 ment? A. Depend on what?

Q. Depending upon mathematical apportionment as you defined it. A. Yes.

Q. What does the time depend upon, the time for the wheel to drop drop? A. That is indisputably the law of gravity. And if you have a certain distance gravity acts for mass motion of a certain amount. You can't change the physical laws.

Q. Dr. Lyman, you have before you the specification, page 15, in which you have a formula equation shown for T_1, and is it being equal to a large number of factors? A. Yes.

Q. What is T_1 in that equation? A. Well, T_1 is time. It states right here (indicating).

Q. Does it depend upon L? A. The time T_1 necessary for the wheel to move from its highest point to the lowest position will be— Well, the way it is quoted.

Q. Dr. Lyman, does that time depend upon the symbol L, the quantity L, whatever it may be? A. No, you must remember that is the law of gravity and we can't change it, and if you have an angle, a length of arm on which it moves, you still move the same distance on the
52 weight but the angle is changed depending on the length of the arm. In other words, if we double the length of the arm for a time distance motion under gravity, if you doubled the length of the arm, why the angle is one-half as much.

Q. What happens to the time? A. You can't change the law of gravity.

Q. Let me ask you this: If you used in that equation a value of L of 2 and a value of L of 1 and pick a road deflection S which remains the same in both cases, would there be a difference in T_1? A. No. You can't change time. As I illustrated in this drawing right here at the bottom, I have a mass on an arm of certain length. Now for the mass to move a specified distance, which occurs in a specified time, or rather a natural law time, the mass moves under the natural law, which is a specified time. It moves for the natural law distance, and the shorter L is why we have a change of the distance so far as the angle, which indicates and establishes where we hook the two together. That is mathematical apportionment.

Q. In other words, then that will determine L, where you will attach the spring? Do I understand what you have just said? A. By

causing the same distance of motion in the same length of time, that is mathematical apportionment.

53 Q. Then that formula would show you where L would go? A. Yes.

Q. And that would be in the illustration you have on the board, L would be the length? A. That is right.

Q. Dr. Lyman, would you turn to page 18 of your application which is before you? Now looking to equation F there— A. Equation what?

Q. Equation F.

THE COURT: On page 18?

MR. NAKAMURA: Excuse me, 15. Equation 15.

THE COURT: Yes, 15.

THE WITNESS: Page, 15, do you mean?

THE COURT: The equation at the top of the page.

THE WITNESS: Oh, yes.

BY MR. NAKAMURA:

Q. Dr. Lyman, I have in my hand here a text book. The name of it is "Vibration Problems in Engineering." It is by Timoshenko. I have the Third Edition of 1955, and on page 29 there is an equation which reads this way:

$$T \simeq \frac{2\pi}{3.530}\sqrt{\frac{WL^4}{EIg}}$$

A. You said 353 instead of 354?

54 Q. Yes. A. Well, they are identical.

Q. Did I understand you to say they are identical? A. I have never seen that particular copy before but that is what is here.

Q. In your application did you disclose that equation as a means for determining the period of vibration of your spring? A. I assume so; yes.

Q. Do you agree that the period of vibration is the number of seconds it takes to make a complete swing, a complete to-and-fro swing? A. Yes.

Q. Would you say that the frequency of vibration is equal to the number of complete swings to-and-fro per second? A. You can calculate it for any time element, but you used that phraseology which is customary for the group to use.

Q. And then the period of vibration is simply obtained by dividing

1 by the frequency then? A. You have got me. I don't know. You are asking me a question that my brain hasn't been oriented to follow through.

Q. Dr. Lyman, would you agree that there are a number of different systems of independent wheel suspensions? A. There is what?

Q. That there are a number of different types? A. Oh, yes. So
55 far as the elements thereof.

Q. You disclosed a suspension system in your application which is of the type in which no radius rod is used? A. Yes.

Q. Would you agree that you have an improvement of an old and well-known type of suspension system? A. Both the radius rod suspensions and the ones without radius rods go back to about 1880, and that was before there was any production in automobiles. So there isn't anything particularly new on the elements that go into a suspension system.

Q. Now I wonder if I might refer you to a drawing in defendant's exhibit 1-D, page 1, the Figure 2? A. Yes.

Q. The link which is shown up there by the reference numeral 23— A. Yes.

Q. Is that of the type which is commonly known as a wishbone link? A. Well, that is a standard type of suspension linkage which has been used in the past on production vehicles. In the olden days the wishbone parts of a suspension were the two angular rods holding the axle in place on the Ford car. That was called the wishbone.

56 MR. NAKAMURA: No further questions at this time, Your Honor.

THE COURT: Have you any redirect?

MR. BOOTH: Just a few questions, Your Honor.

REDIRECT EXAMINATION

BY MR. BOOTH:

Q. Dr. Lyman, referring to the formula shown on page 15 of your application, which derived the time necessary for the wheel to move from its highest point to its lowest point, that you were just mentioning, in the solution of those formulas the factor L is one of the factors that is indicated as influencing the time. Now that would seem to indicate that if the length of the suspension links is changed the time required for the wheel to move downward through a given distance

would also change; is that correct? A. That is not correct. You would change the angle of motion if you changed the links, but you would not change the mass motion under gravity.

Q. Now if we may refer to the model, plaintiff's exhibit 4, would the length of the links affect the total distance through which the wheel could move? A. We are not concerned with the total distance that the wheel could move. We are only concerned with the distance that occurs during the road operation.

57 Q. And this formula that is quoted on page 15 of your application, is that limited to movement within the normal operating range or does it extend to maximum permissible movement? A. Let me show it to you.

Yes, but then we have limits established in the formula, don't we?

Q. I would rather have you tell me. A. Yes, there are limits established in the formula for work. Incidentally, those limits that are established there on the formula mean, so far as the model is concerned that they are on the tangent of the arc of motion substantially in a horizontal position, so that the transverse movement of the wheel is substantially—there might be—it is about 3 or 4 ciphers with some numbers after the period, ciphers into the tens of thousands—such an infinitesimal shift of the wheel that it has no practical value whatsoever.

Q. Is that the effect of including the length of the links as a factor in this formula? A. Yes, that is true.

Q. That is a shift which you say is infinitesimal? A. Yes.

MR. BOOTH: Thank you. I have no further questions, Your Honor.

58 THE COURT: Are both sides finished?

MR. NAKAMURA: Yes, Your Honor.

THE COURT: How much time do you want for a brief? I will need a brief on this. Oral arguments wouldn't do much good. How much time will you need after you have received the transcript ?

MR. BOOTH: I would like 30 days after the transcript, Your Honor.

THE COURT: How about you?

MR. NAKAMURA: That will be satisfactory with me, Your Honor.

THE COURT: Very well.

MR. BOOTH: Do you want simultaneous briefs, Your Honor?

THE COURT: No. You will get an answering brief from Mr. Nakamura, and if you need time to reply to his answering brief you may have it.

MR. BOOTH: You are not setting a time for a reply brief now?

THE COURT: I am giving you 30 days. And then I am giving him 30 days after he receives your brief. Then you will get a copy of his brief and if you desire make a reply ask the Court.

MR. BOOTH: I see. Thank you, Your Honor.

59 THE COURT: And don't forget, I want proposed findings of fact, conclusions of law and an order from both of you.

Court will now adjourn until tomorrow morning at 10:00 o'clock.

THE DEPUTY MARSHAL: This Honorable Court stands adjourned until 10:00 o'clock tomorrow morning.

(Whereupon, at 12:10 p.m. the trial of Civil Action No. 1059-63, Kenneth E. Lyman versus David L. Ladd, Comm'r. of Patents, was concluded.)

[Filed, August 4, 1964]

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

KENNETH E. LYMAN,

Plaintiff,

vs.

DAVID L. LADD,
COMMISSIONER OF PATENTS,

Defendant.

Civil Action
No. 1059-63

OPINION

This civil action was brought pursuant to 35 U.S.C. 145 seeking judgment of this Court authorizing the defendant, Commissioner of Patents, to issue Letters Patent of the United States containing claims 1 through 7 of an application Serial No. 844,408 entitled "Automotive Independent Wheel Suspension System", filed October 5, 1959, by the plaintiff.

The invention described in the application relates to an automotive independent wheel suspension system in which the wheel is connected to the frame of the vehicle for vertical movement by a transverse parallelogram linkage pivotally connected at one end to the wheel and at the other end to the frame of the vehicle. The chassis is supported on the wheels by a cantilever spring fixed to the frame with the end of the spring acting on the linkage. A front wheel is pivotally connected to the parallelogram linkage by a yoke having spaced vertical king pins supporting the wheel for turning movements about an axis lying in the central plane of the wheel to steer the vehicle. The usual shock absorber is eliminated, and greater tire contact with uneven road surfaces is achieved, by mathematical apportionment of the parallelogram linkage relative to the spring. By such mathematical apportionment, the rate of downward movement of the wheel in passing down a bump or into

a depression in the road is made equal to the rate of downward movement of the spring.

The claims read as follows:

Claim 1:

In a vehicle suspension system including a vehicle frame, a wheel, linkage means connecting the wheel to the frame for vertical movement relative thereto and a spring acting on the linkage means urging the frame upward relative to the wheel, the improvement comprising so constructing and proportioning the spring that the frequency controlled rate of downward movement of the point therein which acts on the linkage is equal to the gravity effected rate of downward movement of the point in the linkage acted on by the spring.

Claim 2:

The suspension system of claim 1 in which the wheel is pivotally connected to the linkage means for turning movement about a vertical axis lying in the center plane of the wheel.

Claim 3:

The suspension system of claim 1 in which the time required for the wheel to move from its highest to its lowest position is equal to one-half of the period of vibration of the spring.

Claim 4:

In a vehicle suspension system including a vehicle frame, a wheel, a generally horizontal linkage pivoted at one end to the frame and at the other end to the wheel to support the frame on the wheel, and a spring acting on the linkage and urging the frame upward relative to the wheel, the improvement which comprises so constructing and relating the linkage to the spring as to provide a natural timed downward movement of the linkage about its pivotal connection to the vehicle frame when the wheel moves downward equal to the natural period of movement of the spring whereby there is no resultant transfer of energy between the spring and the linkage when the wheel moves downward relative to the frame.

Claim 5:

The spring suspension of claim 4 in which the spring is a cantilever spring with one end secured to the frame and the other end secured to the linkage to the wheel.

Claim 6:

The spring suspension of Claim 4 in which the wheel is

supported for turning movement about a vertical axis lying in its center plane and carried by a yoke to which the linkage is pivoted.

Claim 7:

The spring suspension of claim 6 in which the linkage is a parallelogram linkage supporting the wheel for parallel movement.

The Examiner in the Patent Office rejected all the claims as unpatentable, stating that they contained subject matter which, as a whole, would have been obvious at the time the invention was made to a person ordinarily skilled in the art. 35 U.S.C. 103. In order to demonstrate this obviousness, the Examiner relied upon a United States patent to Metz, No. 2,202,665, a United States patent to Siebler, No. 2,122,961, and a printed publication entitled "Vibration of Rail and Road Vehicles" by B. S. Cain, pp. 84 to 86 (1940).

The patent to Metz discloses an independent front wheel suspension system in which a wheel is supported by a yoke on spaced vertical king pins for turning movement, and is connected to the frame for vertical movement by a transverse parallelogram linkage pivotally connected at one end to the yoke and at the other end to the frame. A radius arm is also provided, and extends rearwardly from the yoke to a pivot point on the frame. The chassis is supported on the wheels by a transverse, semi-elliptical spring having an end acting on the parallelogram linkage and the center portion attached to the frame. The vertical axis of the king pins is stated to be practically centered in the central plane of the wheel, being offset inwardly by about 1/4 of an inch. The need for a shock absorber is eliminated, and greater tire contact with uneven road surfaces is achieved by a "synchronous balance of operative reaction forces." Metz attributes this balancing of reaction forces to the proportioning of the linkage and radius arm to establish frequencies of functioning of the wheel mass equivalent to the established frequency of the spring. The inner end of the lower parallelogram linkage arm is provided with a shock absorber effective at low speeds and decreasingly effective as speed increases. At speeds in excess of 25 m.p.h., it was found that no undamped forces of significant magnitude are felt.

The patent to Siebler discloses an independent front wheel suspen-

sion for automobiles in which the wheel is carried by a steering swivel connected to the frame by relatively wide upper and lower transverse links pivotally connected at one end to the swivel and at the other end to the frame. A transverse spring is fixed at one end to the frame and pivoted at the other end to the steering swivel. No radius arm is provided.

According to the plaintiffs' brief and the testimony introduced by plaintiff at trial, the essence of his invention resides in arranging the proportions of the suspension linkage and the spring so that no unbalanced forces will be produced between the spring and the linkage when the wheel moves in the downward direction as a result of passing over a depression in the road. The rate at which the mass of the wheel and suspension linkage move downward in response to a depression in the road can apparently be calculated when the dimension of the linkage and other characteristics of the wheel mass and linkage are known. Similarly, the natural frequency of vibration of a cantilever spring can also be mathematically determined when the characteristics of the spring are known. When the time required by the wheel mass to move to a certain distance downward equals the time required for the spring, through its natural frequency, to move downward through the same distance, no unbalanced forces between the spring and the linkage are created. Thus, by using a mathematical equation in which the time for downward movement of the linkage is equated to the time for downward movement of the spring, the physical dimensions of the spring and linkage can be mutually calculated in terms of one another.

The Metz patent describes a suspension arrangement which is predicated upon these very same mathematical relationships. While the patent does not set forth equations, it does state that the result obtained is to eliminate unbalanced forces between a spring and a linkage due to the "synchronous balance of operative reaction forces" in a vehicle wheel suspension unit which is substantially identical to the plaintiff's. Metz attributes this "synchronous balance" to arranging the spring and linkage so the "frequencies of functioning" of the spring and linkage are equivalent at the point of attachment. It would seem to necessarily follow from the "synchronous balance" described that at the point on the linkage acted upon by Metz's spring both the spring and the linkage have

the same rate of downward movement. This latter equivalence of movement at such a point is the essence of the subject matter set forth in plaintiff's claims.

The plaintiff in his brief has made much of the fact that Metz does not provide mathematical equations for explaining his results. It appears to the Court, however, that even though Metz did not chose mathematics for describing what he had done, this should not detract from the fact that he clearly disclosed the concept of balancing reaction forces in a suspension system in a manner substantially identical to that of the plaintiff. In any event, it certainly cannot be said that the mathematical relationship would have been unobvious to a person ordinarily skilled in the art with the Metz patent to guide him.

The Court also finds that plaintiff's arrangement for supporting the wheel for turning movement about a vertical axis lying in the center plane of the wheel would have been obvious in view of the Metz patent. The patentee's axis for supporting the wheel for turning movement differs only insofar as it is off-set inwardly by 1/4 of an inch from the vertical axis claimed by the plaintiff. The Court does not believe this is a patentable difference.

After reviewing the record in the Patent Office, weighing the evidence presented at trial, and studying the briefs submitted by the parties, it is the opinion of the Court that the totality of the evidence is such that the Court cannot say that the Patent Office has erred.

Accordingly, the Court finds for the defendant and against the plaintiff, and hereby dismisses the Complaint.

The above Opinion contains Findings of Fact and Conclusions of Law.

Dated: August 4, 1964.

/s/ Joseph R. Jackson
United States District Judge

[Filed, August 4, 1964]

ORDER

This cause came on for trial on March 3, 1964. Upon consideration of the record herein and the briefs the Court accorded the parties an opportunity to file, it is, this 4th day of August, 1964,

ORDERED, that the Complaint be, and it is hereby dismissed, with all costs of this proceeding to be assessed against the plaintiff.

/s/ Joseph R. Jackson
United States District Judge

[Filed, August 25, 1964]

NOTICE OF APPEAL TO THE UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

Notice is hereby given that Kenneth E. Lyman, Plaintiff above named, hereby appeals to the United States Court of Appeals for the District of Columbia from the Order and Judgment entered on August 4, 1964, dismissing Plaintiff's Complaint.

/s/ N. D. Parker, Jr.
1030 - 15th Street, N.W.
Washington, D.C. 20005

BRIEF FOR APPELLANT.

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT.

No. 18,935

KENNETH E. LYMAN,
Plaintiff-Appellant.

vs.

DAVID L. LADD, COMMISSIONER OF PATENTS,
Defendant-Appellee.

Appeal From the Order of the District Court for the District of Columbia.

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STATEMENT OF QUESTIONS PRESENTED.

The questions are whether in a trial de novo under 35 USC 145 to authorize the Commissioner of Patents to issue Letters Patent: 1. The trial court erred in holding (JA 99) that the invention in issue relates to an automotive independent wheel suspension of a particular type rather than to a specific mathematical apportionment of the mechanical and spring elements of any type of independent wheel suspension. 2. The trial court erred in its application of 35 USC 103 when the prior art relied on, as unequivocally established by the evidence, is based on teachings contrary to the natural laws of physics and mechanics.

INDEX.

Authorities Cited.

Cases.

Statute.

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT.

No. 18935.

KENNETH E. LYMAN,
Plaintiff-Appellant,

vs.

DAVID L. LADD, COMMISSIONER OF PATENTS,
Defendant-Appellee.

BRIEF FOR APPELLANT.

JURISDICTIONAL STATEMENT.

This appeal is from an order of the District Court for the District of Columbia dismissing appellant's complaint against the Commissioner of Patents seeking authorization to issue Letters Patent. Jurisdiction of the District Court is based on the Patent Act of July 19, 1952, c. 950, 66 Stat. 792, U. S. C. A., Title 35, § 145. The complaint (JA 1) names the Commissioner of Patents as defendant, and alleges filing of the application for Letters Patent, final rejection of the application by the Primary Examiner and decision adverse to appellant by the Patent Office Board of Appeals.

Jurisdiction of this court is based on the Act of June 25, 1948, c. 646, 62 Stat. 929, U. S. C. A., Title 28, § 1291. The District Court rendered a final order August 4, 1964 (JA 104). Notice of Appeal to this Court, pursuant to Rule 73 of the Federal Rules of Civil Procedure, was filed August 25, 1964 (JA 104).

STATEMENT OF THE CASE.

Appellant's application for Letters Patent filed September 14, 1959 describes an invention in a particular relationship of the mechanical and spring wheel suspension system for automotive vehicles. The particular relationship forming the gist of the invention is so-called "mathematical apportionment" (hereinafter defined) of the mechanical elements comprising the wheel and its supporting elements, or suspension arms, and the elastic spring elements, whereby unbalanced forces created when wheels strike road ruts or bumps are eliminated. This results in a smooth ride and improved controlability and safety of the vehicle.

Background.

The ideal automotive wheel suspension system would be one in which no vertical movement of the wheels is transmitted to the chassis, and no unbalanced forces or stresses exist between the suspension system and chassis or within the suspension system itself. This would result in a perfectly smooth ride and perfect control of the vehicle under all operating conditions. Such system has never been attained.

Conventional systems, as taught by the prior art and in common use on automobiles for some years past, all involve mechanical suspension elements and spring elements. In these constructions, however, the mechanical and spring elements are not in balance and it is essential that shock absorbers or snubbers be used. Shock absorbers do two things, both of which are deleterious; first, they transfer upward movement of the wheel to the chassis and second, they delay downward movement of the wheel into contact

with the road, thereby reducing controlability of the vehicle and safety. The prior art, however, had no other answer.

Appellant's invention, for the first time, enables the production of a wheel suspension system which not only enables removal of shock absorbers but demands their omission, which minimizes transfer of upward movement of the wheel to the chassis and which provides optimum downward movement of the wheel for maximum road contact, controlability and safety.

The Invention.

This invention, as is true of many important inventions, lies in a concept; namely, mathematical apportionment. This concept, as explained in the original specification (JA 8, 9) can be incorporated in many different types of structures. The one selected for illustration was chosen because its performance characteristics closely approach an ideal system and because the mathematics involved are relatively simple.

Fig. 1 (JA 22) of appellant's patent application shows diagrammatically an automobile frame 10 with wheels 14 attached thereto by suspension elements indicated generally at 15.

Suspension elements 15 consist essentially of two parts: dual suspension arms 23 and 24 best seen in Fig. 3 (JA 23) which connect the wheel assembly (left hand portion of Fig. 3) to the auto chassis 10 through block 16; and elastic spring means 25, illustrated as a simple cantilever spring in Fig. 3 (JA 23), secured to chassis 10 at one end and the wheel assembly at the other. Arms 23 and 24, pivoted to move freely at their points of attachment with the wheel assembly and block 16, form a parallelogram with the wheel assembly and block 16. Thus as the wheel moves up and

down under normal driving to accommodate ruts and bumps, it remains always in vertical plane.

Referring still to Fig. 3 (JA 23) spring 25 supports the auto chassis with respect to the wheel assembly, i.e. the weight of the auto bears down at the point of connection of the spring 25 and chassis 10, and the wheel assembly pushes up at the point of connection of spring 25 and the wheel assembly. In this manner the wheel assemblies support the chassis. In accordance with appellant's invention, spring 25 in the *only* resilient support means between the wheel assembly and the chassis, conventional shock absorbers being entirely eliminated.

It can be seen from Fig. 3 (JA 23) that as the vehicle moves over ruts and bumps, the wheel assembly moves up and down through the parallelogram linkage previously described, the upward movement being resisted by spring 25 which tends always to return the wheel assembly and chassis to the relative position illustrated by Fig. 3.

The elements of the above-described assembly are old and appellant takes no position to the contrary (JA 67). Appellant's invention, and the point of novelty on which appellant predicates patentability, is the invention or discovery of a specific relationship between the frequency of the spring element and the gravity induced rate of downward movement of the mechanical elements of the system such that the wheel and the spring move downward through the same distance in the same time interval without creating unbalanced forces. This appellant calls "mathematical apportionment."

Specifically, it is well known that all springs will vibrate at frequencies dictated by their dimensions. Fig. 6 (JA 23) is illustrative of the vibration pattern of a simple cantilever spring. It is also known that bodies when dropped fall at a velocity determined solely by the force of gravity. Ap-

pellant's concept involves constructing the spring elements and the mechanical elements of the wheel assembly so that, as the wheel moves down under fall of gravity, either into a rut or upon leaving a rise or bump, the end of the spring attached to the wheel assembly moves at the same downward velocity. The practical effect of such coordinated movement is that during downward movement of the wheel, the spring exerts no force on the mechanical elements of the wheel assembly which needs to be damped by shock absorbers or otherwise.

Appellant's specification sets forth detailed mathematical formulae (JA 14-18) by which the rates of downward movement of the spring and of the wheel can be calculated accurately. By differential equations (JA 14-15) expressed in terms of gravity effect, the length of the wheel suspension arm and its angle of rotation (shown diagrammatically in Fig. 5, JA 23), T_1, or the time "necessary for the wheel to move from its highest point to the lowest position" (JA 15) in determinable. Knowing such time, one can calculate the spring characteristics necessary to make downward movement of the spring correspond in time to downward movement of the wheel (JA 17-18). The mathematical development is general, i.e. may be applied to calculate the apportionment of the spring and mechanical elements in any type of independent wheel suspension system. For purposes of illustration appellant uses a simple cantilever spring. There is no issue of adequacy or accuracy of appellant's disclosure.

Appellant's claims are 1 through 7 (JA 29, 30). Claims 1-3 were finally rejected by the Primary Examiner (JA 28a, 28b) as "unpatentable over" a patent to Metz (JA 43-59); claims 4-7 as "unpatentable over" Metz in view of a patent to Siebler (JA 60-62) and a publication by Cain (JA 63-64). The statutory basis for the rejection is 35 USC 103 (JA 101).

The Patent Office Board of Appeals affirmed the Primary Examiner (JA 36-39) and adhered to their decision on reconsideration (JA 40).

In the trial court, Dr. Kenneth E. Lyman, the appellant, testified after qualification as an expert witness (JA 74). Dr. Lyman described the history and problems of constructing wheel suspension systems for automobiles (JA 74-76), discussed the disclosure of the Metz patent (JA 79-82) and distinguished his invention over that described by Metz (JA 86). He further testified that he worked with Metz in building several experimental cars, the last of which utilized the structural elements taught by the Metz patent (JA 77), but that no attempt was made to follow the theory of the Metz patent (JA 79), it in fact being not reproducible (JA 89).

STATUTES.

Patent Act of July 19, 1952, c. 950, 66 Stat. 792, U.S.C.A., Title 35, § 103.

Conditions for Patentability; Non-Obvious Subject Matter.

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. * * *

STATEMENT OF POINTS.

1. The District Court erred in failing to recognize that the invention in issue relates solely to mathematical apportionment of the mechanical elements and spring elements of a wheel suspension system of any configuration, rather than to a particular type of suspension system.

2. In concluding that "the Metz patent describes a suspension arrangement which is predicated upon these very same mathematical relationships" as disclosed in appellant's application, the District Court disregarded and refused to give weight to the natural laws of physics and mechanics and to the evidence of this case.

3. In concluding that

> "Metz attributes this 'synchronous balance' to arranging the spring and linkage so the 'frequencies of functioning' of the spring and linkage are equivalent at the point of attachment. It would seem to necessarily follow from the 'synchronous balance' described that at the point on the linkage acted upon by Metz's spring both the spring and the linkage have the same rate of downward movement."

the Court disregarded and refused to give weight to the natural laws of physics and mechanics which are applicable to mathematical apportionment, the evidence in this case and the disclosure of the Metz patent.

4. In concluding that

> "It appears to the Court, however, that even though Metz did not choose mathematics for describing what he had done, this should not detract from the fact that he clearly disclosed the concept of balancing reaction forces in a suspension system in a manner sub-

> stantially identical to that of the plaintiff. In any event, it certainly cannot be said that the mathematical relationship would have been unobvious to a person ordinarily skilled in the art with the Metz patent to guide him."

the Court disregarded and refused to give weight to the evidence in this case.

5. In concluding that

> "It appears to the Court, however, that even though Metz did not choose mathematics for describing what he had done, this should not detract from the fact that he clearly disclosed the concept of balancing reaction forces in a suspension system in a manner substantially identical to that of the plaintiff. In any event, it certainly cannot be said that the mathematical relationship would have been unobvious to a person ordinarily skilled in the art with the Metz patent to guide him."

the District Court erred in failing properly to apply the pertinent statute, 35 USC § 103, since it was not obvious to thousands of engineers who have designed and built over a million suspension systems.

6. The District Court erred in holding that the patent to Metz, No. 2,202,665 eliminated the need for shock absorbers.

SUMMARY OF ARGUMENT.

Notwithstanding the fact that appellant's invention is directed to an intangible concept, mathematical apportionment, by which one can construct an independent wheel suspension system from known spring and mechanical elements to eliminate unbalanced forces, the court below and the Patent Office erroneously viewed appellant's invention as a specific independent wheel suspension structure. Because the prior art, a patent to Metz, teaches structural elements similar to those used by appellant to exemplify the invention (which similarity appellant has never denied) and because the prior art sought, as does appellant, to eliminate unbalanced forces between the spring and mechanical elements, the court below concluded, as did the Patent Office, that Metz teaches or renders obvious (35 USC 103) appellant's invention.

In fact, Metz teaches a suspension system based on a theory contrary to natural physical laws and without meaning to those skilled in the art. It is thus devoid of anticipatory merit.

Appellant, during prosecution of the application before the Patent Office, pointed out to the Examiner and the Board of Appeals why the Metz system and its theory of operation is erroneous and why the Metz teaching merely confuses and misleads those skilled in the art. The Patent Office ignored the arguments. In the District Court, unrebutted expert testimony established that the Metz system is based on theory violative of physical laws and is not reproducible; that the Metz teaching is confusing, misleading and without technical meaning. The District Court ignored the testimony and sustained the Patent Office position.

The law is clear that prior art teachings which are inoperative and are not obviously correctable by those skilled in art cannot anticipate an operative invention. Here the Metz teaching is not obviously correctable—it is not even understandable. Nevertheless the Patent Office and District Court have ignored all the evidence that the Metz teaching is inoperative and meaningless because based on erroneous physical theory and have held appellant's invention to be an obvious one. Such holding is contrary to the law and the facts and cannot be sustained.

ARGUMENT.

Two basic errors have pervaded this case from the outset, initiated by the Examiner, perpetuated by the Board of Appeals and adopted by the District Court: First, that the invention is a particular wheel suspension structure; and second, that full credence must be given to statements in the Metz patent despite their obvious incorrectness and, in the District Court, despite unchallenged expert testimony indicating such incorrectness.

THE INVENTION IS DIRECTED TO THE MATHEMATICAL APPORTIONMENT OF SUSPENSION ELEMENTS—NOT TO A SUSPENSION STRUCTURE.

Appellant's specification is quite clear in disclosing the essence of the invention. The opening sentence (JA 4, 5) states:

> "This invention relates to the mathematical apportionment of the suspension arm elements and the elastic spring elements in an automotive independent wheel suspension system.
>
> As apportionment is the crux of this invention the scope hereof is limited to said apportionment and said apportionment in combination with certain other system structural elements not herein specifically claimed."

Later the specification says (JA 9, 11):

> ". . . Tests established factually that said [mathematical] apportionment is applicable to any combination of usable physical and elastic elements.
>
> As said apportionment is effective in any usable combination, we have selected one independent wheel suspension design, which has been thoroughly tested,

for the drawings to which reference is made hereinafter.

One reason for the design selected is that the performance characteristics of the system very closely approaches that of the ideal system hereinbefore mentioned.

Another reason for the design selected is that, while the apportionment mathematics can be modified to apply to other suspension system designs, this design has the most simple mathematics of apportionment."

* * * * *

"Mathematical apportionment is a new ratio combination of old elements resulting in a plurality of new desirable effects."

Appellant's claims define the invention in terms of mathematical apportionment, the structural elements *per se* being admittedly old.* Neither the Patent Office nor the District Court contends, and rightfully so, that the claims fail properly to define the invention in accordance with 35 USC 112.

It is clear that the invention defined is an intangible relationship, independent of specific structure. The patent law has long recognized patentability in intangible concepts or relationships which are adequately disclosed and exemplified and which do not depend on specific structure. *Eibel Process Co. v. Minn. & Ontario Paper Co.*, 261 US 45 (1923), *In re Conover*, 304 F. 2d 680 (CCPA, 1962). The invention and claims in the *Eibel* case, held valid by the Supreme Court, involved changing the angle of a traveling wire in a paper machine and are strikingly similar to the instant case.

* The claims are of the so-called "Jepson-type" (from Ex parte Jepson, 1917 C. D. 62) in which the claim form is "In a [system, machine, etc.] . . ., the improvement comprising . . ." The introductory portion of the claim states old structure, the portion after "improvement" stating the novel feature of the invention.

Notwithstanding the nature of appellant's invention and claims, the tribunals below placed undue emphasis on the similarity of appellant's exemplifying structure to the structure of Metz. Appellant has never contended the *structures per se* are different or that his structural elements are *per se* novel.

Specifically, the Examiner, in his Answer to Appellant's Brief before the Board of Appeals, said (JA 31):

> "The alleged invention relates to vehicle spring suspensions"

then launched into a detailed description of specific structural elements described in appellant's illustrative embodiment, comparing them element by element to the prior art. After such comparisons, and without ever indicating a recognition of what appellant's invention is, the Examiner concludes (JA 35):

> ". . . although applicant and Metz utilize different terminology, each teaches the apportionment of the linkage and spring in order to obviate the need for a shock absorber and to increase the period of road contact by the tire. See page 2, column 2, lines 12-21 of Metz wherein proportionment of the parts is mentioned."

The portion of the Metz patent above referred to by the Examiner states nothing more than the desideratum of all prior suspension systems—suppression of unbalanced forces. Metz further discloses shock absorbers and recognizes their necessity, although suggesting without explanation (page 6, column 2, lines 68-73) that they may be unnecessary at high speeds—at a time when they would appear to be most urgently required. Metz admittedly sought to achieve a balance of forces but he does not teach appellant's mathematical apportionment technique nor any other technique, capable of so-doing. The Examiner erroneously held to the contrary.

The Board of Appeals substantially adopted the Examiner's position. After noting that (JA 38):

> "Both the appellant and Metz are concerned with the elimination of resultant or unbalanced forces so as to obviate the necessity of using shock absorbers.",

the Board commits the same error as the Examiner, namely that because appellant's illustrative embodiment employs structural *elements* old in the art, their juxtaposition must be the same as Metz'. The Board states (JA 39):

> ". . . the wheel suspension shown by Metz and described therein inherently functions in the same manner as appellant's . . ."

The District Court, notwithstanding a definite explanation that the structural elements of appellant's invention are old and that the invention lay in the particular relationship of these elements (JA 67), sustained the Board on the rationale that appellant's structural elements are "substantially identical" (JA 102) to those of Metz and Metz sought to eliminate unbalanced forces as does appellant. The Court held:

> "The Metz patent describes a suspension arrangement which is predicated upon these very same mathematical relationships [i.e., mathematical apportionment]. While the patent does not set forth equations, it does state that the result obtained is to eliminate unbalanced forces beween a spring and a linkage due to the 'synchronous balance of operative reaction forces' in a vehicle wheel suspension unit which is substantially identical to the plaintiff's."

The error perpetuated from the outset of this case is simply this: Because Metz teaches structural elements similar to appellant's (which appellant has never denied) and because Metz sought to construct a wheel suspension system to eliminate unbalanced forces (also appellant's

goal), Metz must therefore teach appellant's invention or render it obvious within the meaning of 35 USC 103. As will become manifestly clear Metz suggests only desired results (all of which are old and known) and in fact teaches theory to obtain such results which is violative of physical laws and which misleads and retards the art rather than advancing it.

THE METZ PATENT IS PREDICATED ON THEORY VIOLATIVE OF PHYSICAL LAWS AND THE SYSTEM TAUGHT IS NOT REPRODUCIBLE.

Appellant's Invention.

For an understanding of appellant's mathematical apportionment, it is first necessary to understand the concept that every independent wheel suspension system consists of two basic groups of elements; first, the mechanical elements and, second, the spring elements. The mechanical elements include the wheel and the linkage, whatever its form, which connects the wheel to the chassis or frame. This linkage could constitute the parallel laterally extending links as shown in appellant's drawings which project outwardly from the side of the frame of the vehicle and to the outer ends of which the wheel is connected. Alternatively the linkage could be in the form of a trailing arm or other conventional types of linkages which are well understood in the art. All of these linkages have in common however, that they connect the wheel to the chassis for relative vertical movement.

The second group of elements comprising the spring elements may again take any conventional form. As shown in appellant's drawings, the simplest type of spring consists of a cantilever spring rigidly secured at one end to the frame and extending laterally therefrom to connect at its other end either to the wheel or to the suspension link-

age. Coil springs or other types of springs known in the art could be used equally well and to the same effect.

When the vehicle is at rest or is travelling along a perfectly smooth horizontal roadway, the weight of the vehicle will tend to move the frame downward relative to the wheel thereby moving the wheel upward relative to the frame and creating a deflection of the spring. The amount to which the spring will be deflected depends entirely upon the weight of the vehicle, the spring being deflected until it exerts a force upwardly on the chassis and downwardly on the wheel equal to that part of the vehicle weight borne by the individual wheel.

When the vehicle strikes a bump which causes the wheel to move upward it is apparent that the rate and extent of upward movement of the wheel relative to the frame will be determined solely by the size of the bump and the rate at which the vehicle is travelling. A certain amount of the bump effect will be absorbed by the tire but this may be disregarded for present purposes. However, when the wheel has passed over the bump and again tends to move downwardly relative to the frame the mathematical apportionment of appellant's invention comes into play and it is at this time that the concept of the mechanical and spring elements as independent systems must be considered.

Assuming for purposes of visualization that the chassis tends to remain in its existing plane when the wheel is no longer supported by the bump, the wheel will tend to fall at a rate determined solely and entirely by the force of gravity. The rate at which the wheel will fall will be a close approximation to the rate of free fall of any object under the influence of gravity and may be considered equal to the free fall gravity rate for all practical purposes. Appellant has set forth in his specification (JA 14, 15) mathematical formulae for determining with an extremely high

degree of accuracy the time required for the wheel to fall under the force of gravity from its maximum upward to its maximum downward position within the limits of operation for which the system is designed.* However, Dr. Lyman made it clear in his testimony (JA 97) that the wheel mass motion follows the law of gravity.

At the same time that the wheel starts to move down the point of connection of the spring to the mechanical suspension elements will also start to move down under the natural spring force. The rate at which the spring will move down is determined entirely by the spring characteristics, that is by the designed frequency rate of movement of the spring. It is apparently conceded by all parties to this matter that every spring has a frequency of movement and that its rate of movement is determined by design of the spring which will in turn vary this frequency rate. The mathematical apportionment of appellant's invention comprises so apportioning the mechanical elements of the spring suspension system and the spring elements of the system and so interconnecting the two groups of elements that the downward movement of the mechanical elements

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* The Solicitor in the District Court (JA 93, 94) questioned the fact that the formulae for determining downward movement of the wheel involves the length L of the suspension arms (JA 14, 15). As explained by Dr. Lyman (JA 96, 97) changes in the length of the suspension arms will change the angles through which the links will move and the lateral distance through which the wheel moves when the wheel moves downward through a given distance but will not change the mass motion under gravity of the wheel. He also testified that the effect of a change in length of the links is infinitesimal and further (JA 83) that experiments in which the length of the links was changed showed no detectable difference. Thus, despite the formulae which are mathematically accurate, it can be considered for all practical purpose that the wheel moves straight down under the sole influence of gravity within the operating limits of the suspension system.

in a given time interval will be equal to the downward movement of the spring elements in the same time interval. When this apportionment exists there will be no transfer of forces between the mechanical elements and the spring elements during downward movement of the wheel and there will obviously be no resultant unbalanced forces remaining at the end of the downward movement which are required to be dampened out by a shock absorber.

This action may be likened to the situation existing when a horse is drawing a cart down hill. When the gravity motion of the cart due to the steepness of the hill is exactly equal to the rate of motion of the horse independently of the cart, the horse will be neither pushing nor pulling the cart and there will be no transfer of force between them. On the other hand if the cart tends to coast down the hill faster than the horse is moving, the cart will try to push the horse and the horse will exert a force tending to hold it back. Similarly if the cart is tending to move by gravity slower than the horse, the horse will pull the cart and there will be a transfer of force between them.

While this concept may seem relatively simple it is new and it produces many very important results. In the first place when the wheel rises over a bump, the only change in force exerted on the chassis is the relatively small amount of additional force resulting from additional deflection of the spring. In most cases this is on the order of one or two hundred pounds as distinguished from transfer to the frame through a shock absorber on the order of several thousand pounds under similar operating conditions. Most importantly, appellant's mathematical apportionment enables the wheel to move downward freely at the maximum rate when it passes over the bump or when it passes into a hole or low spot in the road surface. This means that the wheel will be better maintained in maximum contact

with the road surface under all conditions, thus greatly increasing the control the operator has over the vehicle and making a major contribution to safety. It is conservatively estimated that adoption of the present invention on all automotive vehicles, because of the improved control it would impart, would reduce the road deaths by at least sixty-nine percent.

The Metz Patent.

Metz teaches a wheel suspension system the structural elements of which admittedly are similar to those shown in appellant's application. Thus Fig. 4 (JA 46) shows a parallelogram linkage formed by rods 36 and 37 connecting a chassis 11 to a wheel assembly 61. A cantilever spring 14 acts on the wheel whereby the wheel assembly supports the chassis. Metz uses radius torque rods 21 and 22 (Fig. 1, JA 43) to support the wheels 18 and 19 against horizontal fore and aft movement as they strike ruts and bumps. Appellant uses no torque rods but agrees that suspension linkages without torque rods are not new.

Among Metz's stated objects is (JA 51):

> "... to provide a design wherein the ratio, proportions and arrangements of the parts is such that the reactive effects of weight mass, inertia force and the forces of resilient supporting means are self absorbing in the system to the end that no shock absorber action is necessary except when the velocity of the inertia forces in a vertical direction is relatively different from the velocity of the forces of the resilient supporting means."

Manifestly, Metz recognized the problem appellant has solved, that unbalanced forces in wheel suspension systems are undesirable. Appellant has never contended otherwise. However, Metz did not *solve* the problem nor provide any

teaching which could lead to its solution. He certainly does not recognize appellant's concept, i.e., to get a system with no unbalanced forces, one must mathematically apportion the spring and mechanical elements to produce simultaneous independent downward movement thereof through the same distance in the same time interval.

The Metz Theory.

Metz's theory, to which the Patent Office and the District Court gave full credence, is erroneous and without anticipatory significance since it is contrary to the laws of nature. Metz says his mechanical elements have a "frequency of functioning" (JA 55) and more particularly that the "wheel mass . . . has a definite frequency which is a matter related to mass, tire size and amount of air pressure of the tire . . ." (JA 55).

These are incredible statements. Mass, in particular the wheel mass in a suspension system, has no frequency, i.e. periodic vibration. The wheel mass moves vertically downward in response only to gravity and upward in response to bumps. To have a "frequency" some force opposite that of gravity must act periodically. There is no such force. As stated by Dr. Lyman when explaining Exhibit 4, a model wheel suspension system (JA 80-81):

> "The Witness: In this model we represent the wheel by this structure here (demonstrating). The two arms here are the suspension arms and this is the chassis. Now there is no force on this at all with the exception of the force of gravity. There are no forces. There is no frequency of motion of the wheel mass and the suspension linkage. Now that is what Metz states he has. But he doesn't have it because he can't have it. That is against the natural laws. If Metz's statement were true we couldn't be here, because if there is an anti-gravity law gravity couldn't exist. If this anti-gravity law causes this wheel to move up, whereas

gravity makes it fall, if the anti-gravity effect actually exists, that would mean that all matter throughout the complete universe and even each element itself would automatically disintegrate."

* * * * *

"Now this here [referring to a spring] has frequency because a spring has a natural frequency of functioning up and down. But as long as this wheel is suspended with the horizontal suspension arms you can't have frequency. Yet Metz states that he does have that property. And that is the point upon which this case rests."

Because based on false theory, the Metz system is not reproducible. No one knows or can ever calculate the characteristics of Metz's system. Dr. Lyman testified that he worked with Metz to develop a system having the structural elements disclosed in the Metz patent but that no attempt was made to follow the theory of the Metz patent (JA 77, 78). In fact this could not be done as shown by the testimony (JA 89):

"Q. If you were to undertake today to duplicate what was involved in that structure and to work out the design from the teaching of the Metz patent, could you do it? A. I could not, nor no one could, because Metz teaches the existence of something that doesn't exist.

Q. In other words, you would have no way of calculating this frequency of the mechanical elements? A. None whatsoever."

No one concerned with this case has ever seriously contradicted appellant's evidence that the Metz theory is completely erroneous. No one has ever attempted to explain how the frequency of the mechanical suspension elements as referred to by Metz could be determined because it is obviously impossible of determination. It simply does not exist.

Nevertheless the Examiner erroneously accepted the Metz theory as being correct and sound, in the final rejection saying (JA 28a):

> "... Also, it is stated [in Metz] that the wheel mass and radius rod have a definite frequency and the spring has an established frequency and by making the linkage 35, 36 of a proper length a correlated frequency is established."

The same general statement is repeated in the Examiner's Answer (JA 34). The Examiner also accepted Metz' statement that this non-existent frequency of the mechanical suspension elements could be controlled by varying the length of his suspension arms—a statement contrary to fact and the laws of nature and shown to be erroneous by subsequent evidence in this case (JA 83, 97).

The Board of Appeals adopted this same reasoning in its opinion (JA 38) and on Petition for Reconsideration (JA 40). Not only is Metz' scientific explanation unsound (JA 40)- it is completely meaningless. There is not and cannot be a frequency of functioning of the mechanical suspension elements. Any explanation based on its existence can teach the art nothing—it can and has only misled and confused.

In the District Court testimony was presented and explained through models that no such thing as the frequency of the mechanical suspension elements on which Metz relies could exist (JA 80, 81, 86, 87). There was no cross-examination of the witness on this point nor was any evidence or argument to the contrary ever offered.

The District Court in its opinion, however, perpetuated the original Patent Office error by giving full credence to the impossible disclosure of Metz. In his opinion the District Judge said (JA 102, 103):

> "The Metz patent describes a suspension arrange-

> ment which is predicated upon these very same mathematical relationships. While the patent does not set forth equations, it does state that the result obtained is to eliminate unbalanced forces between a spring and a linkage due to the 'synchronous balance of operative reaction forces' in a vehicle wheel suspension unit which is substantially identical to the plaintiff's. Metz attributes this 'synchronous balance' to arranging the spring and linkage so the 'frequencies of functioning' of the spring and linkage are equivalent at the point of attachment. It would seem to necessarily follow from the 'synchronous balance' described that at the point on the linkage acted upon by Metz's spring both the spring and the linkage have the same rate of downward movement. This latter equivalence of movement at such a point is the essence of the subject matter set forth in plaintiff's claims."

This holding is entirely inconsistent with commonly-known physical laws and is directly contrary to the uncontroverted evidence in this case.

Implicit in the proceedings below is the recurring theme that Metz really disclosed a suspension system like appellant's and that appellant has simply duplicated the system, explained its characteristics, given it a name (mathematical apportionment) and defined it by complicated formulae. The Examiner said that Metz and appellant simply "utilize different terminology" (JA 35); the Board on reconsideration, that "Assuming, arguendo, that Metz's scientific explanation of the invention is unsound, the fact remains that [their systems are the same]" (JA 40); and the District Court that, ". . . even though Metz did not choose mathematics for describing what he had done, [Metz disclosed a system] substantially identical to that of plaintiff." Such is the essence of the error. Metz teaches no reproducible system and at most simply sets out the desideratum of all suspension systems, namely no unbalanced forces, and explains such systems by theory contrary to natural law. Such teaching is of no anticipatory value.

AN INOPERATIVE REFERENCE IS OF NO ANTICIPATORY VALUE.

It is axiomatic in the patent law that a reference is good only for what it clearly teaches. *Badische Anilin & Soda Fabrik* v. *Kalle & Co.*, 104 F. 802 (2nd Cir. 1900). In *Dewey & Almy Chemical Co. et al.* v. *Mimex Co., Inc.*, 124 F. 2d 986 (2nd Cir. 1942) Judge L. Hand said:

> "No doctrine of the patent law is better established than that a prior patent or other publication to be an anticipation must bear within its four corners adequate directions for the practice of the patent invalidated. If the earlier disclosure offers no more than a starting point for further experiments, if its teaching will sometimes succeed and sometimes fail, if it does not inform the art without more how to practice the new invention, it has not correspondingly enriched the store of common knowledge, and it is not an anticipation."

If a teaching is inoperative, it is viable as an anticipatory reference only if its error is one obviously correctable by one skilled in the art. As stated in *Bullard Co., et al.* v. *Coe*, 79 App. D. C. 369, 147 F. 2d 568 (1945),

> "In order to show that the appealed claims are inventive, it was necessary for appellant to prove that Svenson [the prior art of record] (1) was not operative and (2) could not be made operative by slight changes within the skill of a competent mechanic, or in other words, without inventive genius."

Where the testimony shows that skilled mechanics or workers in the art can not correct an error in a reference so as to make it operable, such reference is without anticipatory significance. *Manhattan Book Casing Mach. Co.* v. *E. C. Fuller Co.*, 274 F. 964 (S. D., N. Y. 1912). The Patent Office Board of Appeals has held they will not correct an error in a reference so as to make the reference a viable one. *Ex parte Herzog*, 115 USPQ 195 (1956).

Clearly, the error in the Metz patent is not one correctable by the art-skilled. It is a fundamental error in theory which violates physical laws. Once this is recognized by the art-skilled, the Metz patent is of no value in teaching how to obtain by mathematical apportionment a suspension system which accomplishes the result sought by both Metz and appellant. In all proceedings below, this critical fact was ignored.

The testimony of Dr. Lyman is unequivocal and uncontradicted—Metz's system is not reproducible and is based on theory violative of natural laws. Such testimony was ignored by the District Court.

CONCLUSION.

The District Court filed an opinion containing findings of fact and conclusions of law. The findings of fact are clearly erroneous since they completely ignore unrebutted expert testimony. Appellant's claimed invention is not obvious within the meaning of 35 U. S. C. 103 since the prior art teaching, based on erroneous theory, is without anticipatory significance and serves only to confuse and mislead.

Accordingly, the order of the District Court should be reversed.

Respectfully submitted,

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BRIEF FOR APPELLEE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

APPEAL NO. 18,935

KENNETH E. LYMAN, APPELLANT

v.

DAVID L. LADD, COMMISSIONER OF PATENTS, APPELLEE

APPEAL FROM THE JUDGMENT OF THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

CLARENCE W. MOORE,
Solicitor, United States Patent Office,
Attorney for Appellee.

JOSEPH F. NAKAMURA,
Of Counsel.

STATEMENT OF QUESTIONS PRESENTED

In the opinion of the appellee, the questions presented are:

(1) Whether the District Court was clearly wrong in holding, on all of the evidence before it, that the Patent Office tribunals did not err in refusing appellant's patent application claims 1 to 7 for lack of patentable invention over the disclosure of Metz patent No. 2,202,665.

(2) Whether the District Court was clearly wrong in holding, on all of the evidence before it, that the Patent Office tribunals did not err in refusing appellant's patent application claims 4 to 7 for lack of patentable invention over the disclosures of Metz patent No. 2,202,665, Siebler patent No. 2,122,961 and the Cain Vibration publication.

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INDEX

AUTHORITIES CITED

* Cases or authorities chiefly relied upon are marked by asterisks.

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

APPEAL NO. 18,935

KENNETH E. LYMAN, APPELLANT

v.

DAVID L. LADD, COMMISSIONER OF PATENTS, APPELLEE

APPEAL FROM THE JUDGMENT OF THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLUMBIA

BRIEF FOR APPELLEE

INTRODUCTION

Appellant appeals from a decision (J.A. 99) of the United States District Court for the District of Columbia dismissing the complaint (J.A. 1) in an action brought under Section 145 of Title 35, United States Code (Act of July 19, 1952, c. 950, 66 Stat. 803). In the action, the appellant, Kenneth E. Lyman, sought to have the District Court authorize the issuance of a patent on the Lyman application, Serial No. 844,408, containing claims 1 to 7 inclusive (J.A. 100–101). The District Court and the Board of Appeals refused to allow the claims for the reason that they fail to define patentable invention over the prior art under 35 U.S.C. 103.

COUNTERSTATEMENT OF THE CASE

Since the "Statement of the Case" in the brief for appellant (pages 3–7) omits essential facts material to the consideration of the questions presented, a counterstatement of the material facts is deemed necessary.

Appellant's application

Appellant's application (J.A. 4–23) relates to an automotive independent wheel suspension system. As shown in Fig. 3 of the application drawings (J.A. 23), the wheel is connected to the frame 10 of the vehicle by a transverse parallelogram linkage 23, 24, pivotally connected at one end to the wheel and at the other end to the vehicle frame. The chassis is supported on the wheels by a cantilever spring 25 fixed to the frame with the end of the spring acting on the linkage. As further shown in Fig. 3, a front wheel is pivotally connected to the parallelogram linkage by a yoke 22 having spaced vertical king pins 21 supporting the wheel for turning movements about an axis lying in the central vertical plane of the wheel to steer the vehicle. The application discloses (J.A. 6, second and third paragraphs and J.A. 18, second paragraph) that the usual shock absorber is eliminated, and greater tire contact with uneven road surfaces is achieved, by mathematical apportionment of the parallelogram linkage relative to the spring. By such mathematical apportionment, the rate of downward movement of the wheel in passing down a bump or into a depression in the road is made equal to the rate of downward movement of the spring.

The prior art

The Metz patent, No. 2,202,665 (J.A. 43–59), discloses an independent front wheel suspension system. Referring to Fig. 4 (J.A. 46), the system is one in which a wheel is supported by a yoke 43 on spaced vertical king pins 46 for turning movement, and is connected to the frame 11 for vertical movement by a transverse parallelogram linkage 35, 36 pivotally connected at one end to the yoke and at the other end to the frame. As shown in Fig. 1 (J.A. 43), the chassis is supported on the wheels by a transverse, semi-elliptical spring 14 having an end acting on the parallelogram linkage and the center portion attached to the frame. A radius arm 21 is also provided and extends rearwardly from the yoke to a pivot point on the frame.

The patent states (J.A. 55, col. 1, lines 11–16) that the vertical axis of the king pins is practically centered in the central plane of the wheel, being offset inwardly by about ¼ of an inch. The need for a shock absorber is eliminated, and greater tire contact with uneven road surfaces is achieved by a "synchronous balance of operative reaction forces" (J.A. 55, col. 1, lines 42–52 and col. 2, lines 33–40 and 54–73). Metz attributes this balancing of reaction forces to the proportioning of the linkage and radius arm to establish frequencies of functioning equivalent to the established frequency of the spring. The inner end of the lower parallelogram linkage arm is provided with a shock absorber (J.A. 48, Figs. 7 and 8) effective at low speeds and decreasingly effective as speed increases. At speeds in excess of 25 m.p.h., it was

found that no undamped forces of significant magnitude are felt (J.A. 55, col. 2, lines 11–16).

The Siebler patent, No. 2,122,961 (J.A. 60–62), discloses an independent front wheel suspension for automobiles. Figs. 1 and 2 (J.A. 60) show that the wheel is carried by a steering swivel 3 connected to the frame by relatively wide upper and lower transverse links 4 and 7, pivotally connected at one end to the swivel and at the other end to the frame. A transverse spring 5 is fixed at one end to the frame and pivoted at the other end to the steering swivel. No radius arm is provided.

The publication, Vibration of Rail and Road Vehicles by B. S. Cain, 1940, pages 84–86 (J.A. 63–64) discloses the use of differential equations to describe the motion of a spring-supported weight (J.A. 63, Fig. 66) in rolling over a low spot in a road.

The claims on appeal

The claims on appeal, as found in the Opinion of the District Court (J.A. 100–101), are numbered from 1 to 7 and drawn in apparatus form to a vehicle suspension system.

Claim 1 specifies a vehicle suspension system including a spring acting upon linkage connecting the wheel to the vehicle frame, in which the improvement comprises "so constructing and proportioning the spring" that the frequency controlled rate of downward movement at its point of application on the linkage is equal to the gravity effected rate of downward movement of the linkage at that point.

Claim 2 is drawn to the vehicle suspension system defined in claim 1, and specifies that the wheel is pivotally connected to the linkage for turning movement about a vertical axis in the center plane of the wheel.

Claim 3 is drawn to the vehicle suspension system defined in claim 1, and specifies that the time required for the wheel to move from its highest to its lowest position is equal to one-half the period of vibration of the spring.

Claim 4 specifies a vehicle suspension system including a spring acting upon linkage pivotally connecting the wheel to the vehicle frame, in which the improvement "comprises so constructing and relating the linkage to the spring" as to provide a natural, timed downward movement of the linkage about its pivotal connection to the frame equal to the natural period of movement of the spring, whereby there is no resultant transfer of energy between the spring and the linkage when the wheel moves downward relative to the frame.

Claim 5 is directed to the spring suspension defined in claim 4, and specifies that the spring is a cantilever spring with one end secured to the frame and the other end secured to the linkage.

Claim 6 is directed to the spring suspension defined in claim 4, and specifies that the wheel is supported for turning movement about a vertical axis lying in its center plane and is carried by a yoke to which the linkage is pivoted.

Claim 7 is directed to the spring suspension defined in claim 6, and specifies that the linkage is a parallelo-

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gram linkage supporting the wheel for parallel movement.

The grounds for refusal of the claims

The Board of Appeals (J.A. 36–39 and 39–40) and the District Court (J.A. 99–103) found that the claims fail to define patentable invention over the Metz patent (J.A. 43–59), under 35 U.S.C. 103. The Board of Appeals also found (J.A. 36–39) no error in the examiner's view (J.A. 31–36) that further evidence of unpatentability of claims 4 to 7 is found in the Siebler patent (J.A. 60–62) and in the Vibration publication (J.A. 63–64). The District Court held (J.A. 103) that "* * * the totality of the evidence is such that the Court cannot say that the Patent Office has erred."

THE STATUTE INVOLVED

The section of the patent statute involved is Section 103 of Title 35, United States Code. Section 103, in its pertinent part, is set out in the brief for appellant on page 8.

SUMMARY OF ARGUMENT

Appellant has the burden of showing that the District Court was clearly wrong in finding that the claims do not define patentable invention. Appellant has failed to make such a showing.

The Metz patent discloses an independent wheel suspension system having the same combination of structural elements recited in the claim. The features recited in the claims and not shown by Metz would have been obvious to a person of ordinary skill in the art with the Metz patent to guide him. Further

evidence of obviousness is found in the Siebler patent and in Cain's Vibration publication.

Appellant's contention of undue emphasis on structure fails to take into account the fact that the Board of Appeals and the District Court directed specific findings to the mathematical apportionment feature as recited in the claims.

The Metz patent is presumed to contain a disclosure adequate to enable those skilled in the art to make and use the invention. Appellant's new evidence fails to prove that an inadequate disclosure was made by Metz.

ARGUMENT

Appellant's burden of proof

In its Opinion (J.A. 99–103), the District Court ruled (J.A. 103) that "* * * the totality of the evidence is such that the Court cannot say that the Patent Office has erred." In *Johns-Manville Corp.* v. *Ladd,* —— U.S. App. D.C. ——, 328 F. 2d 563, 140 USPQ 362, this Court said:

> * * * [A]s we have frequently stated, the findings of the Patent Office, an expert administrative body, especially when confirmed by the District Court, will not be overturned here unless clearly infected with error. *Zenith Radio Corporation* v. *Ladd,* 114 US. App. D.C. 54, 57, 310 F. 2d 859, 862 (1962).

In the same *Johns-Manville* decision, this Court also stated:

> In assaying the action of the district judge, we note also that his findings "shall not be set aside unless clearly erroneous," particularly where those findings, as here, to some extent at

> least, are predicated on the trial court's judgment of the credibility of the witnesses appearing before it. Rule 52(a), F.R. Civ. P.

Appellant accordingly has the burden of proving that there is no rational basis in the evidence before the District Court for its decision agreeing with the Patent Office tribunals that claims 1 to 7 are not patentable.

Unpatentability over the prior art

Claim 1, quoted as representative by the Board of Appeals (J.A. 37), reads as follows (J.A. 100):

> In a vehicle suspension system including a vehicle frame, a wheel, linkage means connecting the wheel to the frame for vertical movement relative thereto and a spring acting on the linkage means urging the frame upward relative to the wheel, the improvement comprising so constructing and proportioning the spring that the frequency controlled rate of downward movement of the point therein which acts on the linkage is equal to the gravity effected rate of downward movement of the point in the linkage acted on by the spring.

Comparing the structure recited in this claim with that disclosed in the Metz patent (J.A. 43–59), it is apparent that Metz includes a "vehicle frame" designated 11 in Fig. 4 (J.A. 46), a wheel represented by the brake drum 67 and "linkage means" including transverse parallel links 35 and 36 for "connecting the wheel to the frame for vertical movement relative thereto." A spring designated 14, and acting on the linkage means, is provided in Metz for "urging the frame upward relative to the wheels."

Metz, thus, shows the same combination of vehicle frame, wheel, linkage means and spring that is recited in claim 1. From mere inspection of the other claims 2 to 7 (J.A. 100–101) it is apparent that, except for claim 6, the other claims call for this combination of elements. Claim 6 in addition specifies a "yoke" on which the wheel is carried, and "to which the linkage is pivoted." Metz shows such a yoke, designated 43 in Fig. 4 (J.A. 46).

It is apparent, then, that the only recitations in the claims not found in Metz are (1) the references to so constructing and proportioning the spring (or so constructing and relating the linkage to the spring) as to provide equal rates of frequency controlled downward movement of the spring and gravity effected downward movement of the linkage at the point of attachment of the spring to the linkage, and (2) the references in claims 2, 6 and 7 to the location of the turning axis of the wheel. It is respectfully submitted that the Board of Appeals and the District Court were correct in finding (J.A. 36–40, 99–103) that those features would be obvious to a person of ordinary skill in the art.

The Metz patent states (J.A. 55, column 1, lines 42–72):

> In the design of a construction for independently mounting vehicle wheels, if the component parts are such as to establish frequencies of functioning substantially equivalent to the frequencies of the spring arrangements, no exterior means, such as a shock absorber, is necessary as a component part of the mechanism because the function of the shock absorber is to bring

> to rest unbalanced or undamped forces which are incident to the operation of an unbalanced mechanism.
>
> * * *
>
> This wheel mass and that portion of the weight of the torque radius rod which may be considered a part of the wheel mass has a definite frequency which is a matter related to mass, tire size and amount of air pressure of the tire, and the car spring also, by design, has an established frequency of functioning similar to a tuning fork. By making the length of the parallelogram linkage (35 and 36) of proper length a correlated frequency of functioning is established.

The Metz patent further states (J.A. 55, column 2, lines 17–40):

> In résumeé * * * (8) there is what may be termed synchronous balance of operative reaction forces which is obtained by the frequency control established by the parallelogram length, the spring frequencies, the character, arrangement and location of the radius torque rods, the load point of application and an actual reaction frequency of unsprung weight.

Metz thus describes a synchronous balance of operative reaction forces which is obtained by so constructing and relating the linkage to the spring as to produce equivalent frequencies of functioning of the spring on the one hand and the wheel and linkage on the other hand.

The claims, as noted, call for so constructing and relating the linkage to the spring as to produce equal rates of downward movement of the linkage and the

spring at the point in the linkage acted upon by the spring. Appellant calls this feature "mathematical apportionment" (Br. 5, 19–20). The Board of Appeals found suggestion of the equal rates of downward movement of the linkage and spring in the disclosure of the Metz patent. The Board of Appeals stated (J.A. 38):

> We are unable to draw any other meaning from the description on page 6 of Metz, starting with line 42, than the proper proportionment of the spring and the combined mass of the wheel, the laterally extending arms and the radius rod so as to have the same frequency of function, namely, so as to move together to prevent unbalanced forces.

The District Court found (J.A. 102–103):

> It would seem to necessarily follow from the "synchronous balance" described [by Metz] that at the point on the linkage acted upon by Metz's spring both the spring and the linkage have the same rate of downward movement.

It would appear self-evident that in the absence of an unbalanced force, the spring would neither accelerate nor retard downward movement of the linkage. Appellant's example (Br. 20) of the horse and cart clearly illustrates this fact. Certainly a worker of ordinary skill in the art of independent wheel suspensions would realize this self-evident fact. It is suggested that the District Court was clearly correct in finding (J.A. 102):

> The Metz patent describes a suspension arrangement which is predicated upon these very same mathematical relationships [appellant's

> equal rates of downward movement of the spring and the linkage].

It is further suggested that the District Court was clearly correct in finding (J.A. 103):

> * * * In any event, it certainly cannot be said that the mathematical relationship would have been unobvious to a person ordinarily skilled in the art with the Metz patent to guide him.

Claims 2, 6 and 7, as noted above, include references to the location of the turning axis of the wheel. These claims (J.A. 100–101) require the turning axis to be in the center plane of the wheel. In Metz the turning axis, as noted by the District Court (J.A. 103), is off-set inwardly by ¼ of an inch. There is, however, no evidence that this difference in the location of the turning axis produces any unobvious, different result. To the contrary, Metz suggests (J.A. 55, column 1, lines 11–41) the advantages described in appellant's application specification (J.A. 18, last paragraph). Particularly persuasive suggestion would seem to be provided by Metz's statement (J.A. 55, column 1, lines 11–19) that his turning axis is "practically centered." It is submitted that the Board of Appeals was correct in finding (J.A. 39) that appellant's location of the turning axis would be obvious, and that the District Court was correct in finding (J.A. 103) that "* * * plaintiff's arrangement for supporting the wheel for turning movement about a vertical axis lying in the center plane of the wheel would have been obvious in view of the Metz patent."

In addition to agreeing with the Board of Appeals

that appellant's claims are not patentable over Metz, the District Court ruled (J.A. 103) that "* * * the totality of the evidence is such that the District Court cannot say that the Patent Office has erred." The Board of Appeals found (J.A. 37–38) no error in the examiner's finding (J.A. 35) that the Siebler patent and the Vibration publication constitute further evidence of unpatentability. It is urged that this finding is also supported by the record.

As noted above, the Siebler patent (J.A. 60–62) shows an independent wheel suspension in which no radius arm is used. The Vibration publication (J.A. 63–64), as also noted above, shows the use of differential equations to describe the motion of a spring-supported weight in rolling over a low spot in a road. Appellant presented no evidence showing error in the examiner's views (J.A. 35) that it would be obvious, in view of the Siebler patent, to omit the radius arm 21 of Metz, and that it would be obvious, in view of the Vibration publication, to use differential equations to determine the length of the parallelogram linkage when the radius arm is omitted. It is submitted that the Board of Appeals was clearly correct in finding no error in those views of the examiner.

Appellant asserts in his brief (page 15): "Metz further discloses shock absorbers and recognizes their necessity, although suggesting without explanation (page 6, column 2, lines 68–73) that they may be unnecessary at high speeds—at a time when they would appear to be most urgently required." However, from mere inspection of Figs. 7 and 8 of Metz (J.A. 48), it is apparent that the shock absorbers are not

conventional shock absorbers but rather are what Metz describes (J.A. 55, column 2, lines 60–67) as "* * * the shock absorbers or motion damping means on the inner ends of the lower parallelogram arms or links * * *." Elimination of conventional shock absorbers is apparent in the statements by Metz that (J.A. 55, column 1, lines 42–52) "* * * the function of the shock absorber is to bring to rest unbalanced or undamped forces * * *," and that (J.A. 55, column 2, lines 11–16) "* * * under all normal operating speeds, (speeds in excess of 25 m.p.h.) no undamped forces of any magnitude are felt in the operation of the mechanism." Significantly, appellant's application specification (J.A. 4–23) reveals that appellant's suspension system is designed for "road travel" which the specification defines (J.A. 5) as "* * * a car operating speed of more than 25 mph and road irregularities of height not to exceed the action limit of the suspension."

Appellant, himself, gave further evidence of the elimination of conventional shock absorbers in Metz when he testified at the trial (J.A. 77, midpage):

> * * * I road tested Metz's jobs for approximately 165,000 miles.
>
> * * *
>
> When he came to this last design that particular structure which is shown in Metz's patent was applied to my own personal car. That was the one that was built to fit my car. And I ran a lot of tests on it and the Borg-Warner group were active in it and one of the automotive companies placed an order for it. But then the automobile company was given orders

> to drop it *on account of the pressure that was put on by shock absorbers, the shock absorber people and others.* [Emphasis added.]

The Board of Appeals, moreover, noted (J.A. 40, mid-page) that the necessity for shock absorbers is eliminated in Metz. It is submitted that it cannot be tenably contended (Br. 10, Statement of Points No. 6) that there is no reasonable basis for the finding by the District Court (J.A. 101) that the need for a shock absorber is eliminated in Metz.

The allegation of undue emphasis on structure

In his brief (pages 15–16), appellant quotes portions of the Examiner's Answer (J.A. 31, 35), Board of Appeals decision (J.A. 38, 39) and Opinion of the District Court (J.A. 102), all allegedly showing (Br. 15) "* * * undue emphasis on the similarity of appellant's exemplifying structure to the structure of Metz." Appellant stresses the fact (Br. 14) that "Appellant's claims define the invention in terms of mathematical apportionment, the structural elements *per se* being admittedly old."

"Mathematical apportionment," as noted above, refers to the feature of so constructing and relating the linkage to the spring as to produce equal rates of downward movement of the linkage and the spring. The following statement directed to this feature is found in the decision of the Board of Appeals (J.A. 38):

> We are unable to draw any other meaning from the description on page 6 of Metz, starting with line 42, than the proper proportionment of the spring and combined mass of the

> wheel, the laterally extending arms and the radius rod so as to have the same frequency of function, namely, *so as to move together* to prevent unbalanced forces. [Emphasis added.]

The following statement directed to this feature is found in the Opinion of the District Court (J.A. 103):

> In any event, it certainly cannot be said that the mathematical relationship would have been unobvious to a person ordinarily skilled in the art with the Metz patent to guide him.

The alleged inoperative disclosure of the Metz patent

Appellant contends (Br. 17): "The Metz patent is predicated on theory violative of physical laws and the system taught is not reproducible." Appellant states (Br. 22):

> Metz says his mechanical elements have a "frequency of functioning" (JA 55) and more particularly that the "wheel mass * * * has a definite frequency which is a matter related to mass, tire size and amount of air pressure of the tire * * *"(JA 55).

Appellant contends (Br. 22)

> Mass, in particular the wheel mass in a suspension system, has no frequency, i.e. periodic vibration. The wheel mass moves vertically downward in response only to gravity and upward in response to bumps. To have a "frequency" some force opposite that of gravity must act periodically.

Appellant produced no evidence other than his own testimony and two models (J.A. 80, 81) at the trial to show that the Metz disclosure is predicated on a

false theory. Appellant emphasizes in the brief (page 22) his testimony at the trial in which he stated (J.A. 81):

> The Witness: In this model we represent the wheel by this structure here (demonstrating). The two arms here are the suspension arms and this is the chasse. Now there is no force on this at all with the exception of the force of gravity. There are no forces. There is no frequency of motion of the wheel mass and the suspension linkage. Now that is what Metz states he has. But he doesn't have it because he can't have it. That is against the natural laws. If Metz's statement were true we couldn't be here, because if there is an anti-gravity law gravity couldn't exist. * * *

This testimony, however, has reference to a demonstration of a stationary model. A stationary model manifestly is no evidence that other forces due to wheel mass, tire size and air pressure do not exist when a wheel under load passes over irregularities in a road surface.

Appellant contends (Br. 23): "Because based on false theory, the Metz system is not reproducible. No one knows or can ever calculate the characteristics of Metz's system." The Metz patent, however, is presumed to be valid, and therefore to comply with the statutory requirement for a description of the invention in such terms as to enable any person skilled in the art to make and use the described invention. See Sec. 35 U.S.C. 112, first paragraph (formerly R.S. 4888), reproduced in the appendix to this brief. The burden is on the appellant to prove that the invention

is not described by Metz in such terms as to enable any person skilled in the art to make and use the same, and all doubts are resolved against the appellant. See *Western States Mach. Co.* v. *S. S. Hepworth Co.,* 147 F. 2d 345 (CCA 2, 1945), Certiorari denied 325 U.S. 873. It is respectfully submitted that, on the sole strength of Dr. Lyman's testimony, appellant has not sustained his burden.

Appellant in his brief (page 11) asserts that the District Court ignored Dr. Lyman's testimony. The District Court in its Opinion, however, stated (J.A. 103) that its decision was reached "After reviewing the record in the Patent Office, *weighing the evidence presented at trial,* and studying the briefs submitted by the parties, * * *." [Emphasis added.] While the Court made no specific finding as to Dr. Lyman's testimony, this Court stated in *Schilling* v. *Schwitzer-Cummins Co.,* 79 U.S. App. D.C. 20, 142 F. 2d 82:

> Certainly we should not require or encourage trial judges, in preparing findings, to assert the negative of each rejected contention as well as the affirmative of those which they find to be correct.

CONCLUSION

It is respectfully submitted that, for the foregoing reasons, the conclusions reached by the Board of Appeals and the District Court that the claims at bar are not patentable over the patents and publication cited in the decision of the Board of Appeals are correct and have a reasonable basis in the record, and that under the standard of review reiterated by this

Court in *Johns-Manville Corp.* v. *Ladd,* supra, the judgment of the District Court should be affirmed.

Respectfully submitted.

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JOSEPH F. NAKAMURA,
Of Counsel,

DECEMBER 1964.

APPENDIX

35 U.S.C. 112. SPECIFICATION

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention. * * *

U.S. GOVERNMENT PRINTING OFFICE: 1964

REPLY BRIEF FOR APPELLANT.

IN THE

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT.

No. 18,935

KENNETH E. LYMAN,
Plaintiff-Appellant,

vs.

DAVID L. LADD, COMMISSIONER OF PATENTS,
Defendant-Appellee.

Appeal From the Order of the District Court for the District of Columbia.

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AUTHORITIES CITED.

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No. 18935.

KENNETH E. LYMAN,
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vs.

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Defendant-Appellee.

REPLY BRIEF FOR APPELLANT.

Appellee's brief raises several points requiring rebuttal.

Counterstatement of the Case.

The solicitor in his counterstatement of the case (Br. 2-6) indicates that "essential facts material to the consideration of the questions presented" were omitted from appellant's "Statement of the Case".

He then proceeds with a detailed description of the structure shown in the drawings of the illustrative embodiment of appellant's invention and devotes over a page of his brief to describing the claims (Br. 4-6) and structural detail recited therein. Appellant has admitted, in his application as filed (J. A. 4, 5, 9, 11), and at every stage of prosecution since, that his invention is not in structure, but in a novel mathematical apportionment of *known* structural elements.

As stated in the specification of appellant's application:

> "As apportionment *is the crux* of this invention the *scope* hereof *is limited* to said apportionment and said apportionment *in combination* with certain other system structural elements *not* herein specifically *claimed.*
>
> * * * * *
>
> Another reason for the design selected is that, while the apportionment mathematics can be modified to apply to other suspension system designs, this design *has the most simple mathematics of apportionment*" (Emphasis added).

Thus, instead of supplying "essential facts", allegedly "omitted" by appellant, the solicitor merely perpetuates the error made by the Patent Office and the District Court of comparing, part by part, appellant's admittedly old structure with admitted prior art structures.

Appellant's claims, as pointed out in the main brief (Br. 14) specifically recite that the invention is an "improvement", that the improvement is in a manner of apportionment of spring and mechanical elements, and that *all* structure is admittedly old. (See the footnote at appellant's main brief, p. 14). The Jepson-type claim is used expressly for this purpose.

Structural novelty of appellant's illustrative embodiment is not the issue—appellant has always agreed there is none. The only issue is whether mathematical apportionment—admitted by the solicitor to be novel—is obvious under 35 U. S. C. 103.

Appellant's Burden of Proof.

The solicitor notes that appellant has the burden of proving clear error in the District Court's decision. Appellant agrees.

However, in citing *Johns-Manville* v. *Ladd*, ... US App. DC ...., 328 F. 2d 563 (Br. 7), the solicitor fails to note the most pertinent portion:

> "Nevertheless, the trial court was justified in placing great weight on the findings of the Patent Office since '*the Patent Office finding must be accepted, if it is "consistent with the evidence*," the Patent Office being an expert body pre-eminently qualified to determine questions of this kind'" (Emphasis added).

The "Patent Office finding" in the instant case is clearly not "consistent with the evidence". Dr. Lyman's testimony, the only oral testimony in the case, shows unequivocally that the disclosure in the Metz patent, the foundation for the Patent Office position, is erroneous, misleading and not reproducible.

As to credibility of witnesses, Dr. Lyman, the only witness, was qualified as an expert*, which qualification was never questioned. He was not cross-examined regarding his expert conclusions of the basic error in the Metz disclosure, nor was any contrary explanation of the Metz disclosure offered.

Appellant manifestly has sustained his burden of proof in accordance with Rule 52(a), F. R. C. P. by showing that the finding of the District Court was clearly erroneous in light of uncontroverted expert testimony.

Appellant's Invention.

In attacking appellant's evidence, the solicitor says (Br. 17):

> "This testimony, however, has reference to a demonstration of a stationary model. A stationary model

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* In fact the District Judge said, (J. A. 74):
The Court: I think the doctor [Dr. Lyman] has *more than sufficiently qualified* himself to testify as an expert (Emphasis added).

> manifestly is no evidence that other forces due to wheel mass, tire size and air pressure do not exist when a wheel under load passes over iregularities in a road surface''.

This statement is confusing and totally irrelevant. The model was used at the trial simply to explain that the mechanical elements and spring elements of wheel suspension systems function as independent units (J. A. 91). It is this fact of independence which makes the concept of mathematical apportionment possible. Using the model, appellant explained that there is no force acting on the mechanical elements creating a ''frequency of motion'', as Metz alleges. Such force would be ''anti-gravity'' which, of course, is non-existent. I.e. there is no force, opposite to that of gravity, which acts on matter to give it ''frequency''.

Clearly the forces to which a wheel is subjected when passing over irregularities in a road surface create no ''frequency of motion''. They are uncontrollable external forces which cause the wheel and mechanical elements to rise. The elements then fall under the force of gravity. Mathematical apportionment of the invention deals solely with internal forces between spring and mechanical elements during downward movement, not external forces acting on the wheel.

The Inoperative Disclosure of the Metz Patent.

The solicitor notes that the Metz patent is ''presumed to be valid'' (Br. 17) which means, *inter alia,* that as to the *invention claimed* it conforms to the requirements of 35 U. S. C. 112 (Br. 20). He further notes that doubts as to whether a disclosure conforms to 35 U. S. C. 112 should be resolved against appellant (Br. 18), citing *Western States Mach. Co.* v. *S. S. Hepworth Co.,* 147 F. 2d 345 (2nd Cir. 1945).

Appellant, contrary to the solicitor's implication, does not attack the validity of the Metz patent. The invention *claimed* by Metz relates only to a specific suspension structure, as to which the patent is presumed to be valid. This presumption, however, does not attach to every statement not essential to support the claimed invention such as Metz's erroneous explanation of equating of frequencies of mechanical and spring elements. Further, any such presumption cannot be maintained in the face of evidence that it is erroneous and cannot be the basis for holding appellant's mathematical apportionment to be obvious.

The *Western States* case at page 350 says:

> ". . . but a prior patent need not be perfect in order to anticipate; defects which can be corrected *by ordinary skill* will not destroy it as a reference" (Emphasis added).

If the basic error in Metz's unclaimed theory were correctable by ordinary skill, it would seem that, before now, a suggestion for its correction would be forthcoming. However, neither the Patent Office, the District Court nor the solicitor have ever offered any such explanation.

Unpatentability Over the Prior Art.

The solicitor admits (Br. 9), and rightly so, that Metz fails to teach mathematical apportionment. The brief says:

> "It is apparent, then, that the only recitation in the claims *not found in Metz* are . . . (defining mathematical apportionment) . . ." (Emphasis added).

Thus the sole statutory basis for the rejection is 35 U. S. C. 103, the Patent Office admitting that Metz does not anticipate appellant's invention (35 U. S. C. 102a) but only contending that Metz renders it "obvious" with the meaning of 35 U. S. C. 103.

The solicitor, as did the District Court, supports the holding of obviousness by reference to portions of the Metz disclosure which have been unequivocally discredited by expert testimony to be of no anticipatory merit because false, misleading and confusing.

As stated by the Board of Appeals in *Ex parte Gladstone*, 64 U. S. P. Q. 103 (1944):

> "While it makes an easy way of disposing of a case to note the exact margin of novelty and then rule that invention is lacking therein, such unsupported holding does not ordinarily carry conviction that the thing was obvious to one skilled in the art. The question of obviousness is best considered from the view point of the nearest pertinent prior art available".

The Patent Office and District Court have done just what was condemned in *Gladstone*—they admit that mathematical apportionment is novel but hold it obvious notwithstanding that the "nearest pertinent prior art" is Metz* the pertinent portions of which are totally discredited by uncontradicted expert testimony.

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* The Siebler patent discussed by the solicitor (Br. 13) is relied on only to show a wheel suspension system with structural elements similar to Metz but without radius arms. Appellant has never contended that structures like Metz's without radius arms are *per se* new.

The Cain publication is also discussed. It teaches nothing more than the applicability of the mathematics of differential equations to define systems of movement. Appellant has never contended that he was first to define systems of movement by differential equations.

Thus Metz is the closest prior art and the secondary references in no way suggest or teach mathematical apportionment; nor does the Patent Office or District Court so contend.

For reasons herein expressed as well as those expressed in appellant's main brief, the order of the District Court should be reversed.

Respectfully submitted.

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